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No. 2101

TECHNICAL REPORT

CALLIGRAPHY FOR COMPUTERS

by

A.V. HERSHEY

Computation and Analysis Laboratory



U. S. NAVAL WEAPONS LABORATORY
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ABSTRACT

Consideration is given to the possibility of providing a computer and a cathode ray printer with an unlimited repertory of characters. Digitalizations are presented for mathematic, cartographic, and calligraphic characters. The repertory is available to any computer through FORTRAN IV programming. The latest cathode ray printers are almost adequate for the preparation of mathematical reports. Some progress has been made toward development of a mnemonic code for the recording of a mathematical text on tape.

FOREWORD

The work of this report represents an advance in the application of computers. Programming and computation were charged to the Foundational Research Program of the Naval Weapons Laboratory, Project No. R360FR103/2101/R0110101. Character displays were programmed for the NORC cathode ray printer by W. H. Langdon, and for the STRETCH cathode ray printer by Mrs. E. J. Hershey. The photo-microgram of Figure 1 was prepared by J. P. Rucker. Dot plots were prepared on an S-C 4010 printer at the Naval Weapons Laboratory and vector plots were prepared on an S-C 4020 printer at the Naval Ship Research and Development Center. The manuscript was completed by 1 Aug 1967. The Japanese Lexicon was checked by Educational Services of Washington, D. C.

APPROVED FOR RELEASE:

/s/ BERNARD SMITH
Technical Director

INTRODUCTION

Although computers are used primarily for arithmetic, there are other ways in which computers can be used for the saving of labor. The use of computers and cathode ray printers for typesetting^{1,2} is receiving much attention at the present time. Publishers are interested in the possibility of reducing the cost of printing and scientists are interested in the possibility of improving the versatility of printing.

The objective of the present investigation is to explore the feasibility of utilizing the computers and cathode ray printers at the Naval Weapons Laboratory for the preparation of mathematical reports. In this connection a large repertory of digitalized characters has been prepared. The repertory was intended to correspond in scope to the repertories of the American Institute of Physics³ and the American Mathematical Society⁴. The virtuosity of the cathode ray printer has been explored further with a number of calligraphic digitalizations.

Although a number of printer systems² currently are under development, it is assumed in the present report that the Linotron equipment of the Mergenthaler Linotype Company and the Charactron equipment of the Stromberg-Carlson Corporation may serve as examples to illustrate representative qualities, speeds, and versatilities. The repertory in the present report is intended to fill a need for a system which does not sacrifice too much quality or speed, but is unlimited in versatility.

A digitalization of characters was undertaken originally at the Naval Weapons Laboratory⁵ for use on dot plotters. An improved version of the original digitalization is presented herewith as Appendix A. With the exception of a few of the characters, no

attempt was made to vary line thickness.

A digitalization of characters has been prepared recently at the Bell Telephone Laboratories⁶ for use on vector plotters. Line thickening was achieved through the use of multiple lines one raster unit apart. The style of character has been limited so far to Roman and Greek lower case and upper case. The remarkable success of the line thickening has been a stimulus to an extension of the same technique to exotic graphics.

The digitalizations at the Naval Weapons Laboratory and at the Bell Telephone Laboratories complement each other insofar as they do not overlap from the standpoint of style or height of character.

A digitalization of characters is currently under preparation at the Naval Weapons Laboratory for use on vector plotters. Details of the current digitalizations are presented herewith as Appendix B. The scope of the digitalizations is indicated by the following table.

CHARACTER DIGITALIZATIONS

I SIMPLEX

Roman, Greek, Script, Numeric, FORTRAN, Electronic, Cartographic.

II DUPLEX

Roman, Greek, Italic, Futura, Script, Russian, Numeric, Mathematic, Astronomic, Musical.

III TRIPLEX

English Gothic, Italian Gothic, German Gothic.

IV JAPANESE

Hiragana, Katakana, Kanji.

Some of the alphabets in the table have been given new names because they are not identical with existing alphabets. The word simplex has been selected to describe those alphabets which are composed of lines of uniform thickness and have no serifs or flourishes. The simplex style of character is known otherwise as gothic*, sans serif, grotesk, light face, or block letter. The word complex may be applied to those alphabets which are composed of lines of variable thickness and do have serifs or flourishes. The complex style of character includes those which are known otherwise as standard, modern, boldface, or black letter. The words uniplex, duplex, multiplex may be used to express the number of lines which are used in parallel to obtain a variation in line thickness.

Three sizes of characters are provided by the repertory in Appendix B. Characters 9 raster units in height are available for FORTRAN or cartographic applications. Characters 13 raster units in height are available for indexical lines of print. Characters 21 raster units in height are available for principal lines of print.

PRINTING SYSTEMS

Character Generation

In cathode ray printing systems, characters are displayed on the face of a cathode ray tube and are photographed by a camera. Two distinct methods are used for the creation of a character on the face of the cathode ray tube. In one method, a character is created by a beam of electrons which is shaped by its passage through an aperture in a matrix. In the other method, a character is created from the strokes of an electron beam with a constant sweep rate.

*Only in America is the term gothic applied to this style of character.

The space occupied by a character and the time required to create the character are constant for shaped characters but depend upon the size and complexity for stroked characters. In order to compare the methods of creating characters, weighted averages of space and time are required. Weighted averages may be derived through summation of the product of space or time for each character by the frequency of occurrence of the character as utilized in cryptology⁷.

Shaped characters and stroked characters both may be created with the Charactron printers.

Charactron Printers

The cathode ray printers at the Naval Weapons Laboratory consist of an S-C 4010 printer¹¹ on line to the Naval Ordnance Research Computer, and an S-C 4010 printer¹² off line to the STRETCH computer. These are dot plotters and have no vector plotting capability beyond axis generation. The shaped characters occupy 8 raster units of width and require 58 microseconds of time. The matrix contains only 64 characters. Stroked characters can be plotted with the aid of vector simulation subroutines, or the characters can be created out of dots as in Appendix A. A representative weighted average of width for dot plots is 17 raster units and a representative number of dots per character is 22. The plotting of each dot requires 85 microseconds of time.

In the S-C 4020 printer¹³ a vector plotting capability is added to the dot plotting capability of the S-C 4010 printer. Stroked characters can be created out of vectors as in Appendix B. A representative weighted average of width for vector plots is 18 raster units and a representative number of vectors per character is 19. The time to plot each vector depends upon the time to decode the plot instruction and the time to sweep the vector. A representative decoding time is 85 microseconds and a representative sweep rate is $\frac{1}{2}$ raster unit per microsecond. The size of the raster is 1024 X 1024.

In the S-C 4060 printer^{14, 15} the speed and repertory have been increased. Four sizes of shaped characters are provided, and the shaped characters require 11 microseconds of time for creation. The matrix contains 115 characters and includes both lower case and upper case. Four sizes of plotting dot are provided. A representative decoding time is 15 microseconds and a representative sweep rate is 2 raster units per microsecond. The size of the raster is 3072×4096 and the size of the raster unit is the same on both axes. The longer dimension of the raster is in the longitudinal direction on the camera film. The fineness of the raster cannot be utilized fully for stroked characters because of limitations on the fineness of resolution. The smallest plotting dot is three raster units in diameter according to measurements on a specimen of hard copy.

Linotron Printers

In the Linotron printer the characters are stored as photographic images on four glass plates. Any selected character is scanned photoelectrically in a succession of horizontal sweeps across the character block. The photoelectric signal is displayed on a cathode ray tube. The selection, enlargement, and deflection of each character all are performed electrically. The time to create a character depends upon the size of character. For 6, 8, 10 point sizes of character the printing speed is quoted¹⁶ at 1000, 800, 620 characters per second, respectively. The characters are of graphic arts quality on an $8 \times 10\frac{1}{2}$ inch page size. The repertory includes 1020 characters of which a few are mathematical. However, the present scope of the Linotron project does not extend to chemical and mathematical composition.*

Relative Speeds

Insofar as the data in the above considerations are representative

*The existing repertory does not include the integral sign or the partial differential symbol.

of actual performance, the data in the following table are representative of printing speeds.

Printing System (stroke vs shape)	Printing Speed (characters/second)
Dot plot on S-C 4010	530
Vector plot on S-C 4020	550
Vector plot on S-C 4060	2200
Print on Linotron	620
Print on S-C 4010	17400
Print on S-C 4020	17400
Print on S-C 4060	90000

The above estimates do not include the time on a general purpose computer which would be required for the preparation of input to the cathode ray printers.

RESOLUTION

Model

In order to gain some insight into possible factors in the resolution of a cathode ray printer, an analysis will be made on a specific model in which the raster on the cathode ray screen covers an area 10 cm X 10 cm square and contains 1024 X 1024 raster units. It will be assumed that hard copy from the cathode ray printer covers an area 6" X 6" and is viewed by a reader's eye at the conventional distance of 10".

Acuity

A limiting factor is the acuity of the eye. Any resolution in excess of the amount which can be perceived would be wasted. The acuity of the eye varies among individuals, and the acuity varies with the type of perception. Insofar as the perception of separation between lines is a gauge of acuity, the angle of resolution¹⁰ is 30" of arc or a quarter of a raster unit.

Diffraction

An interesting factor is the diffraction of electrons or light in the printer system. The diffraction pattern of a circular aperture consists of alternating bright and dark rings around the geometric center. The angle θ which is subtended by the diameter of the first dark ring is given by the equation

$$\theta = 2.44 \frac{\lambda}{d} \quad (1)$$

where λ is the wave length and d is the diameter of the circular aperture. The wave length for electrons is given by the equation*

$$\lambda = \sqrt{\frac{150}{V}} \times 10^{-8} \text{ cm} \quad (2)$$

where V is the voltage through which the electrons have been accelerated before diffraction.

The paths of the electrons which enter an aperture of the matrix have some dispersion of direction because of the finite aperture of

*This equation is given in the Encyclopaedia Britannica⁸ but not in the Handbook of the American Institute of Physics⁹!

the electron gun, and the dispersion is increased further by diffraction at the aperture. Regardless of the dispersion, all electrons which emanate from a given point in the aperture would be brought to a focus at a common point on the screen if the focusing were perfect.

The effect of diffraction applies to the aperture of the focusing system. It is assumed that the electrons are at 3300 volts when they are diffracted at an aperture of 1 cm diameter and at a distance of 50 cm from the cathode ray screen. The diameter of the first dark ring is computed to be less than 3×10^{-5} raster units and the effect of electron diffraction is negligible.

It is assumed that the cathode ray screen is coated with RCA phosphor No. 11 which has a peak intensity of emission at a wave length of 4600 \AA . It is assumed that the camera is operated at a lens aperture of $f/5.6$. The diameter of the dark ring of optical diffraction is calculated then to be 0.064 raster units.

Grain Size

It is assumed that the diameter of the grains of the phosphor is 5 microns. The grain diameter then corresponds to one twentieth of a raster unit. That the grain size is small also on the film in the camera is indicated by Figure 1. This photomicrogram is a $650 \times$ magnification of a dot which has been recorded on film in the NORC cathode ray printer.

Aberration

One factor which affects resolution is the effect of aberration on the focusing of the electron beam. A diffuse character of the plotting dot can be discerned in Figure 1. The diffuseness may be greater still in a cathode ray printer which is not maintained in perfect adjustment. The diffuseness has the beneficial effect in a dot plotter of making it

possible for a series of closely spaced dots to merge into a continuous line. The diffuseness has the deleterious effect in a vector plotter of bridging small gaps or of filling small openings in the characters. Due allowance must be made in the design of the characters to avoid these unacceptable effects. A gap in a line may be smaller than the opening within a circle without undue bridging or filling.

Dot Size

From densitometer readings it has been determined that the effective diameter of the plotting dot is 2.9 raster units for the S-C 4010 printer. A diameter of 2.3 raster units has been reported⁶ for the S-C 4020 printer. That the diameter could be as small as one raster unit for the same printer is implied by measurements on the hard copy sample from the S-C 4060 printer. It is evident that the cathode ray printers do not achieve the ultimate in resolving power.

The diameter of the plotting dot in a vector plotter should be a minimum in order to give a maximum control of line thickness. The diameter must be no less than one raster unit in order that solid areas may be swept out. The fineness of strokes which can be printed on current cathode ray printers is limited by dot size and not by raster size.

Raster Size

A line of text in a mathematical document should be long enough so that the mathematical equations which are inserted in the text only rarely need to be broken with part on one line and part on another line. With the model herein adopted for analysis, the length of a line of text is 6". If this were typewritten in elite style at 12 characters per inch there would be 72 characters per line of text.

If the line of text were printed with stroked characters at 18 raster units per character, then 1296 raster units would be required per line of text. This is not too many characters per line. Although the number of characters per line is less than 72 for the texts of the American Institute of Physics⁹ or the American Mathematical Society⁴, it may be more than 72 for the texts of the Cambridge University Press¹⁷.

Requirements

It seems apparent that the S-C 4010 and the S-C 4020 cathode ray printers do not have small enough plotting dots and large enough rasters to meet the requirements for the printing of mathematical texts. The S-C 4060 cathode ray printer could meet the requirements if the plotting dot were truly 2 raster units in diameter and the starting and stopping of vectors were controlled to within a raster unit.

CHARACTER DESIGN

Design Criteria

There would be no problem in copying any existing character if the cathode ray printer did not have a finite plotting dot and a finite raster size. The problem of design arises from the need to make a compromise between the three factors of smallness, smoothness, and legibility. It is desirable to make the characters as small as possible so that as many characters can be printed on a line of print as possible. It is desirable to make the edges of curved lines smooth so that characters may have a professional appearance. It is essential that there be no loss of legibility because of bridging or filling of small gaps. The finest detail in any character of an alphabet sets a limit on the smallness of character for the whole alphabet.

The problem of digitalization is to locate successive points in a relatively coarse grid such that vectors can be drawn between the points with optimum results. The absolute position of the successive vectors is not so important as the relative orientation of the successive vectors. With an application of ingenuity it often is possible to achieve a pleasing effect with the polygonalization of curved lines. The limitation on digitalization which is imposed by the finiteness of the grid constitutes an artistic challenge. It is not obvious a priori that all of the characters of interest can be digitalized.

Character Size

A satisfactory polygonalization of a small circle is not possible for a circle of any arbitrary size. The number of sides of the polygon is related to the size of the polygon. The smallest sizes are an octagon of 4 or 6 raster units diameter and a dodecagon of 8 raster units diameter. The next two sizes are hexadecagons with 10 or 14 raster units diameter. The choice of diameter is related to the fact that the polygon appears round only if it has the same radius at 45° inclinations as it has at 0° or 90° inclinations. The products of $\sqrt{2}$ and the smallest integers are approximately integral only if the integers are 5 or 7.

From a mathematical standpoint, an ellipse would be polygonalized by a polygon which is tangent to the ellipse at the point of contact between ellipse and polygon. The ellipse may be found by simultaneous solution of the equation

$$\frac{x^2}{a^2} + \frac{(y - b)^2}{b^2} = 1 \quad (3)$$

for the ellipse, and the equation

$$\frac{dy}{dx} = - \frac{b^2}{a^2} \frac{x}{(y - b)} \quad (4)$$

for the slope of its tangent. In these equations a and b are principal radii of the ellipse. Solution leads to the equation

$$\frac{y}{x} = \frac{-1 + \sqrt{1 + \frac{a^2}{b^2} \left(\frac{dy}{dx} \right)^2}}{\frac{a^2}{b^2} \frac{dy}{dx}} \quad (5)$$

Along a side of the polygon, x and y are related linearly, and the slope dy/dx is constant. The point of tangency between ellipse and polygon may be found by the solution of two simultaneous linear equations in x and y . A number of solutions have been obtained, but only the solutions in the following table are within reasonable bounds.

Side of Polygon	Height of Ellipse
$y = \frac{1}{4}(x - 2)$	$2a = 22.0$ for $\frac{b}{a} = \frac{2}{3}$
$y = \frac{1}{3}(x - \frac{3}{2})$	$2a = 18.5$ for $a = b$
$y = \frac{1}{2}(x - 1)$	$2b = 18.5$ for $\frac{a}{b} = \frac{2}{3}$

The height for polygonalization is not well defined but seems to range from 18 to 22 raster units.

Professional printers measure the size of type in points such that one inch equals 72 points. The point size of type is the normal distance from the base line of one line of type to the base line of the next line of type. The design of character within a character block depends upon the amount of white space which is to be provided between lines of type. Printers often increase the white space to more than normal with additional leading between lines of type. The normal distance from one line to the next is one em, which is subdivided further into printers units such that one em equals 18 units.

A natural correlation between mechanical printing and cathode ray plotting would be achieved if a printer's unit were equated to an integer number of raster units. Insofar as a representative height of character is 12 printer's units, a representative height of character would be 12 or 24 raster units.

In the printing of mathematical texts the principal line of type is printed in 10-point type while the indexical lines of type are printed in 6-point type. The sizes of character in raster units should be compatible with two kinds of line of type.

In the Roman alphabet some lower case letters are two-thirds as high as the upper case letters. The height of the upper case letters should be a multiple of three. Many lower case letters are round, while several upper case letters are oval. The Arabic numerals have round parts. The various round characters should be coordinated with small circles. In the Italic alphabet there are slant lines of various lengths. The projection of each slant line on the horizontal axis is a small integer. For a given slope of line the height of line can have only a few values. Typical slopes for actual Italics are 1 to 3 or 4.

The above considerations have led to a choice of 14 raster units as the basic width and 21 raster units as the basic height of the upper case letters of principal lines of type, and a choice of 10 raster units as the basic width and 13 raster units as the basic height of the upper case letters of indexical lines of type.

Character Space

Calligraphers²⁵ advocate the use of the style of Roman lettering on the Trajan column. This style may be appropriate for architecture but the letters vary greatly in width. Inasmuch as the lettering in the present alphabets is intended to be used interchangeably in words of a text or as symbols in a graph, the letters have been designed to appear

uniform in width.

Calligraphers^{21, 22} agree that the white spaces within letters and between letters should have a uniform distribution along a line of print. This is not really possible in the presence of the letter pairs AA or VV, but these letter pairs are rare. The spacing which should be allotted to each letter varies with the environment in which the letter is situated, and it even has been proposed that the width of the letter itself should vary with its environment. In the present alphabets each character block is allotted its own width, but the width can be changed to any other value as may be desired under program control in the computer.

Character Style

The digitalizations of simplex alphabets are adaptations of the alphabets on Le Roy lettering sets. The digitalizations of complex Roman, Greek, Italic, Russian alphabets are adaptations of the alphabets to be observed in newspapers, text books, and dictionaries^{18, 19}.

Script and Gothic Alphabets

Originally there was only one style of Roman lettering, but the need for a rapid cursive handwriting resulted in a rounding of angularity with the formation of the uncial style of lettering. Now there are two sets of characters for each style of lettering. The majuscules are used for initials and are known otherwise as capitals or upper case letters. The minuscules are used for text, and are known otherwise as small letters or lower case letters. Further evolution of the minuscules resulted in Script for writing and Gothic for printing.

Characters from these alphabets are borrowed occasionally by mathematicians to represent special quantities.

Digitalization of the script alphabet has been adapted from a Headliner Typemaster of the Varityper Corporation. The first Gothic alphabet has been adapted from a Le Roy lettering set for Old English and is called English Gothic. The second Gothic alphabet represents a large family of alphabets for which there does not seem to be a consistent nomenclature. Some writers refer to it as Gothic uncial while others call it Lombardic Gothic. It seems to have been developed in Lombardy while the best examples²³, ²⁴ seem to come from Spain. The present version is an adaptation of a font of the American Type Founders Company²⁰. It is being named Italian Gothic because of its Lombardic origin. The third Gothic alphabet is an adaptation of Fraktur²⁵ and is named German Gothic.

Musical Symbols

The digitalization of musical symbols depends upon the spacing between the lines of the staff. A whole note can be centered over a line only if its height is an even number of raster units. The note can be centered between lines if the spacing between lines is even. A whole note can straddle a line without undue filling and numerals 13 raster units high can be used for measure signs if the spacing between lines is selected to be 10 raster units.

Japanese Characters

The ultimate challenge to calligraphy for computers is the imitation of brush strokes in Chinese and Japanese characters. An investigation has been made to determine the feasibility of digitalization of the Japanese characters. The results are given in Appendix C. The results even have been used for the preparation of an abstract of a Naval Weapons Laboratory report in Japanese as well as in French and German.

Originally the Japanese had no way to write the Japanese language⁸¹. Chinese characters were introduced into Japan along with Confucianism and Buddhism. The structure of a majority of Chinese characters consists of two parts. One part defines the meaning while the other part defines the pronunciation. The two parts often are so selected as to express a logical or poetic meaning for the character.

The Chinese characters are used as stems of many words. Two or more Chinese characters often are grouped together to form compound words. The Chinese characters are called *kanji* by the Japanese. A character dictionary lists 5500 Chinese characters of common occurrence in the modern literature. There are many more in the classical literature. Many of the *kanji* have been simplified, and in November 1946 the Japanese Ministry of Education selected 1850 *kanji* to be used in newspapers and official documents. These are called *Tōyō Kanji* or current characters. They constitute much too restricted a list for technical writing, and even the abstract which is referred to above is not confined to the list.

Parts of certain Chinese characters have been abstracted by the Japanese to form two phonetic syllabaries. The phonetic characters are called *kana* by the Japanese. The *hiragana* syllabary is used as the inflection of words and the *katakana* syllabary is used for foreign words or telegrams. There are 48 basic characters in each phonetic syllabary. Some of these may be modified by diacritical marks or *nigori* to make 25 additional characters. The number of phonemes is 73 for each syllabary.

Each Chinese character has one or more pronunciations of Chinese origin which are called *on*. The Chinese characters for common things also have a Japanese pronunciation which is called *kun*. When Chinese characters are used individually or with a Japanese inflection they are given the *kun* pronunciation. When they are joined together in a compound word they are given the *on* pronunciation. There are only 326 *on* pronunciations to be distributed among 5500 characters. Each

on pronunciation applies therefore to many characters. Ambiguity is avoided insofar as each *on* occurs only within the context for which it has a unique interpretation. The pronunciations can be transliterated into the Roman alphabet in accordance with the Hepburn system. The Romanization is called *rōmaji* by the Japanese. Certain vowel sounds are suppressed while others are lengthened in certain pairs of *kana* which are transliterated into distinct phonemes. There are 114 phonemes in the *rōmaji*.

The structure of each Chinese character consists of one or more parts. One part of every character is called a radical. There are 214 radicals. Many of the radicals are themselves complete characters, while other radicals no longer are used except as parts of characters. To find a character in a character dictionary the first step is to recognize the radical in the character. The radicals are listed serially in the order of increasing number of strokes in the index of the dictionary. All characters with the same radical are listed together in the order of increasing number of strokes in the body of the dictionary. The problem of finding a character thus is reduced to the scanning of a relatively small number of pages in the dictionary.

Character Selection

In view of the large number of characters in a character dictionary, severe limitations had to be imposed on the selection of characters for digitalization. The scope of selection of characters was limited to three sets of characters. The first set includes those radicals which are members also of the *Tōyō Kanji* list. The second set includes those characters which are taught to the Japanese children in the first grade. The third set is a selection of characters of scientific interest. A character which was found to be a component of two or more compound characters was certain to be included. If one character of a pair of antonyms was accepted, the other character was included also, or if

one character of a set of characters was accepted, other characters in the set were included. It was impossible to cover more than a small part of any one subject, and the list of characters is illustrative rather than comprehensive, but it should be well balanced as far as it goes.

The choice of characters was checked by a closed circuit through the dictionaries ²⁶⁻³⁵. Starting with an English to *kanji* dictionary, the *kanji* for a selected English word was found, then continuing with the character dictionary, the *rōmaji* of the given *kanji* was found, and ending with a *rōmaji* to English dictionary, the *kanji* and English for the given *rōmaji* were found. Thus the final English word could be checked against the initial English word.

In the character dictionaries each character is followed first by the *on* pronunciation, second by the *kun* pronunciation, with English translations wherever possible, and finally by a table of compounds wherein the character appears. Although many of the individual characters no longer are used alone and appear only as components of compounds, they still are given archaic English translations, which would unbalance an abridged list of morphemes. Furthermore, certain grammatical morphemes do not occur in the character dictionaries because they have only phonetic renderings. It appears that the best way to illustrate the use of digitalized characters is by a dictionary listing analogous to Sanseido's³⁸. Each entry in the listing is punched on a separate punch card in the order *rōmaji-kanji-kana-English*. The deck of cards may be sorted, abridged, or augmented easily. Its present status is illustrated in Appendix D.

Each character in Nelson's dictionary³² is assigned its own number, whereas the characters in other dictionaries are located by page number. Inasmuch as the numbering in Nelson's dictionary provides a natural and definite identification, it has been adopted for the numbering of digitalized characters. It is easy to recover the character

by its number from the dictionary.

The style of character which seems most promising for digitalization is represented by the simplified square characters in Nelson's dictionary ⁸². These contain hairline horizontal strokes, tapered inclined strokes, and heavy line vertical strokes. Before the characters can be digitalized a decision must be made as to the conversion factor to be used for length from inches to raster units.

Character Conversion

The simplest character of all is No. 0001 (*ichi* = one). It consists of a horizontal line with a triangular spot at the right end. The thickness of the line is 0.010 in. and the length of the line is 0.270 in. The triangle has a base line of 0.060 in. and an altitude of 0.040 in. The vertex of the triangle is 0.010 in. to the left of the center of its base line.

Character No. 0768 (*jū* = ten) differs from character No. 0001 by the addition of a vertical stroke. The horizontal stroke is reduced to a thickness of 0.005 in. and a length of 0.260 in. The triangle has a base line of 0.055 in. and an altitude of 0.034 in. The vertical stroke has a thickness of 0.032 in. and a height of 0.258 in.

Character No. 2170 (*ki* = tree) differs from character No. 0768 by the addition of a pair of diagonal and curved strokes which extend downward to the left and to the right from the center. The horizontal stroke has a length of 0.254 in. and the vertical stroke has a height of 0.263 in. This character occurs as the radical of an especially large number of other characters. When it is used as a radical it is compressed horizontally. In character No. 2379 (*ki* = opportunity) the horizontal stroke has a length of only 0.093 in. The triangular spot has a base line of 0.030 in. and an altitude of 0.020 in.

Thus the thickness and size of components vary in ranges which depend upon the range of fineness of detail. In order to reproduce the above ranges of line thickness and triangle size the conversion may be determined to be 0.011 inches per raster unit. This provides two widths of vertical stroke and three sizes of triangle provided the plotting dot is not more than one raster unit in diameter, and due allowance is made for the thickness of line.

A critical determination of the conversion of length is provided by those characters where there is a set of equally spaced parallel strokes. The space between strokes must conform to an integral number of raster units. Any change of space between strokes then is magnified to a large change in the space allowance for the set. Measurements of spacing have been made upon sixty characters. From the measured distance which spans each set of equally spaced strokes it is possible to compute a distance per raster unit for every possible number of raster units per space. When these distances are plotted together for comparison it becomes apparent that there is a tendency for certain distances per raster unit to persist from character to character. There is some persistence around 0.011 inches per raster unit while there is a stronger persistence around 0.0055 inches per raster unit. The second value would allow the horizontal strokes to have just the right thickness for a full representation of detail but the characters would be twice as large.

Critical examples of characters with many equally spaced strokes are given in the table on the next page.

Character Number	Inches per Raster Unit	Inches per Raster Unit	Translation
0272	0.0115	0.0057	<i>koto</i> = fact
2141	0.0098	0.0059	<i>ryō</i> = quantity
2160	0.0108	0.0054	<i>kumoru</i> = cloud up
3113	0.0117	0.0053	<i>sara</i> = dish
3127	0.0103	0.0055	<i>me</i> = eye
4608	0.0112	0.0056	<i>kuruma</i> = vehicle
4883	0.0108	0.0054	<i>hagane</i> = steel

This table illustrates the degree of correlation between values for the conversion factor.

Although all characters are centered within the same square block, the overall size of many characters is not well defined because pointed strokes radiate outward in all directions from the interior. The size is really well defined only for those characters which are enclosed in a square radical. Examples with square enclosures are illustrated in the following table.

Character Number	Width	Height	Stroke Count	Translation
0868	0.165	0.155	3	<i>kuchi</i> = mouth
2994	0.178	0.188	5	<i>ta</i> = rice field
1028	0.190	0.202	6	<i>mawaru</i> = go around
1037	0.202	0.220	8	<i>kuni</i> = country
1045	0.208	0.233	12	<i>ken</i> = circle

The dimensions in the table are center to center between horizontal strokes or between vertical strokes in the external enclosure. The dimensions increase with complexity to a maximum of 21 raster units

when the conversion factor is assumed to be 0.011. This is compatible with the standard size of Roman alphabet.

The digitalizations in the present investigation are limited to characters with a nominal height of 21 raster units. With some omission of detail in tight spaces and some overflow in complicated cases this size is believed to be adequate for all characters in Nelson's dictionary except No. 5444. Inasmuch as this character represents dragons in motion, it is of doubtful utility. The remaining characters either have been simplified or can be digitalized without too much distortion provided the minimum spacing between lines can be as small as two raster units. Even character No. 5444 can be digitalized when the nominal height of character is 42 raster units.

DOT DATA

Smooth straight lines can be generated with a dot plotter only in limited directions where the discrete increments ΔX , ΔY from one dot to the next have simple integral values. Primary directions are generated when the lines are defined by the increments

$$(\Delta X, \Delta Y) = (2, 0)$$

$$(\Delta X, \Delta Y) = (2, 1)$$

$$(\Delta X, \Delta Y) = (1, 1)$$

or by any permutation of magnitude or reversal of sign among these increments. Secondary directions are generated when the lines are defined by alternation between the following pairs of increments

$$(\Delta X, \Delta Y) = (2, 0), (2, 1)$$

$$(\Delta X, \Delta Y) = (1, 0), (2, 1)$$

$$(\Delta X, \Delta Y) = (1, 1), (2, 1)$$

or by permutations or reversals among these. Jogs in the lines become perceptible when more elaborate patterns are used. The linear characters A, K, M, N, V, W, X, Y, Z contain a variety of inclined lines and limitations on the possible inclinations determine the shapes of the characters. The Roman style of character is available to a dot plotter, but the inclinations for an Italic style of character would be too exaggerated.

Dot plotting on NORC is accomplished by either of two character plotting routines. Block No. 0130 gives a mathematical repertory while Block No. 0160 gives a cartographic repertory. These NORC subroutines have been converted recently to FORTRAN IV by the Control Data Corporation.

The digital data for each character are packed in the data array of each subroutine. The data consist of decimal digit pairs. The first digit pair gives the half width of the character. The second digit pair gives the X -displacement and the third digit pair gives the Y -displacement to the first dot. The subsequent digit pairs give displacements to successive dots. In each of these digit pairs the first digit is the X -displacement and the second digit is the Y -displacement. Negative displacements are expressed by 9's complements. Whenever the first digit is 5, the previous displacement is repeated a number of times equal to the second digit. If the digit pair is 00, the next four digits are interpreted in the same way as the second and third digit pairs, except that displacements are relative to the last plotted dot. The digit pair 50 signifies the end of character.

The decimal format for NORC data is not suitable for STRETCH programming. Inasmuch as the NORC word is 16 decimal digits long and the STRETCH word is 64 binary bits long, there can be a one to one correspondence between the BCD datum word for NORC and the binary datum word for STRETCH. One decimal digit with 9's complements in NORC is mapped into three integer bits and one sign bit in STRETCH. An array of coordinates for dot plotting is recovered from memory by interrogation of a pair of STRAP subroutines.

Replacement of FORTRAN programming by STRAP programming in the character plotting routines has achieved a 7-fold reduction in machine time.

VECTOR DATA

Smooth straight lines are no problem for a vector plotter, but curved lines are approximated by polygons. Small polygons are constructed from short vectors whose components ΔX , ΔY have the following integral values

$$\begin{array}{lll}
 (\Delta X, \Delta Y) = (1, 0) & (\Delta X, \Delta Y) = (1, 1) & \\
 (\Delta X, \Delta Y) = (2, 0) & (\Delta X, \Delta Y) = (2, 1) & (\Delta X, \Delta Y) = (2, 2) \\
 (\Delta X, \Delta Y) = (3, 0) & (\Delta X, \Delta Y) = (3, 1) & (\Delta X, \Delta Y) = (3, 2) \\
 (\Delta X, \Delta Y) = (4, 0) & (\Delta X, \Delta Y) = (4, 1) & \\
 (\Delta X, \Delta Y) = (5, 0) & &
 \end{array}$$

or have any permutation of magnitude or reversal of sign among these values.

In the composition of a character, the ordering and the direction of vectors are immaterial for any cathode ray printer which is correctly adjusted. In order to minimize chaos in the sequence of vectors, the vertical strokes are recorded first and the horizontal strokes are recorded last. Directions are consistently from left to right and from top to bottom. This conforms more or less to the stroke sequence for hand drawn letters. A different sequence might improve the efficiency of a mechanical plotter by a reduction of the amount of motion in a pen up status.

The traditional origin of coordinates for digitalization would be on the base line of the character and at the left edge of the character block. The origin of coordinates for the alphabets at the Bell Telephone Laboratories is situated in the upper left corner of the character block. The origin of coordinates for the characters at the Naval Weapons Laboratory is situated centrally in the interior of the character. This simplifies the centering of isolated characters in cartographic applications and provides a common center line for mixtures* of fonts. Otherwise the origin is arbitrary and the data may be referred to any other origin by a relatively simple subroutine.

The digital data for each character are recorded in a separate block on tape. Each block consists of 16 decimal digit words. Each word is divided into four fields of four digits each. The first word is a beginning-of-block word and the last word is an end-of-block word. Each field of digital data is divided into two digit pairs. The first digit pair of the first field gives the left edge of the character block. The second digit pair of the first field gives the right edge of the character block. Each of the remaining fields give coordinates of a point. The first digit pair gives the X -coordinate and the second digit pair gives the Y -coordinate of the point.

*Examples of mixtures include large parentheses around built up fractions or Roman symbols in a Japanese text.

Negative coordinates are expressed by 9's complements. A vector is plotted between each successive pair of points. A field of 5000 signifies the end of a string of connected vectors. When this field is sensed, plotting is terminated at the last point and is resumed at the next point. A field of 5050 signifies the end of the character.

The raw data are not suitable for efficient machine computation. They must be reformatted in binary mode in such a way as to minimize the memory which is required to store them and to minimize the programming which is required to synthesize printer instructions from them. Although the synthesis of printer instructions could be done in FORTRAN, it is doubtful if this would be as efficient as a synthesis of printer instructions in machine language. STRAP routines are under development for conversion and extraction of data on STRETCH.

REPORT PREPARATION

The usual method for preparing reports at the Naval Weapons Laboratory consists in the typing of a manuscript with an ordinary typewriter which is fitted with Typits. The report herewith was prepared on a Varityper. Six decisions must be made before a character can be struck. These are concerned with horizontal position, vertical position, character style, character size, keyboard bank, and typewriter key. The many errors which occur are painted over or are cut out and replaced laboriously with corrective patches. The alternative would be the typing of the report on a paper or magnetic tape, which could be rewritten and corrected as many times as necessary. Once a correct tape has been achieved, all further conversion and printing becomes automatic. Writing on tape has the disadvantage that the typist must be trained to use function codes. All coding should be mnemonic or phonetic as far as possible without undue complication.

DISCUSSION

The effective utilization of a large repertory depends upon the development of an adequate mnemonic code which a typist can be trained to use. Experimental codes have been described by Barnett⁸⁶. Certainly the alphameric characters will serve as input to Roman alphabets. There is available a convenient transliteration of Greek into Roman for mathematical applications. This transliteration is more nearly isomorphic than isophonic. The phonetic transliterations of Greek, Russian, and Japanese should serve for linguistic applications.

The primary criterion for a choice between character designs is based on what looks best. Attempts to apply mathematical rules have not been entirely adequate. The ultimate criterion certainly is subjective and is an aspect of gestalt psychology. The end of a line seems to have less importance geometrically than it has psychologically. The apparent interaction between a character and the environment in which it is situated may be an application of the adjacency principle of Gogel⁸⁷.

CONCLUSION

It can be concluded that the preparation of mathematical reports is almost within the reach of the latest cathode ray printer equipment.

REFERENCES

1. *Symposium on Electronic Composition in Printing.* National Bureau of Standards, Gaithersburg, Maryland, June 15-16, 1967
2. *Automatic Typographic-Quality Typesetting Techniques. A State of the Art Review.* M. E. Stevens and J. L. Little, National Bureau of Standards Monograph 99 (7 April 1967)
3. *Style Manual.* American Institute of Physics, New York (1959)
4. *A Manual for Authors of Mathematical Papers.* Bulletin of the American Mathematical Society, Vol. 68, p. 429 (1962)
5. *Subroutines for the NORC CRT Printer.* A. V. Hershey, Naval Weapons Laboratory Report No. 1686 (9 March 1960)
6. *Three Fonts of Computer Drawn Letters.* M. V. Mathews, Carol Lochbaum, Judith A. Moss, Bell Telephone Laboratories, Murray Hill, N. J. (Private Communication, 1967)
7. *Cryptology.* Encyclopaedia Britannica, Vol. 6, p. 848 (1965)
8. *Electron Diffraction.* Encyclopaedia Britannica, Vol. 8, p. 245 (1965)
9. *American Institute of Physics Handbook.* D. E. Gray, Editor (McGraw Hill Co., New York, 1963)
10. *The Physiology of the Eye.* H. Davson (Little, Brown and Co., Boston, 1963) p. 103
11. *NORC High-Speed CRT Printer Programming Manual.* F. M. Urvinitka, NPG Report No. 1620 (October 1958)

12. *CRT Printer Programming Manual*. W. G. Ward, NWL Technical Memorandum No. K-12/62 (July 1962)
13. *Programmers' Reference Manual, S-C 4020 Computer Recorder*. Stromberg-Carlson Corporation Document No. 9500056 (August 1965)
14. *S-C 4060 Stored Program Recording System. Description and Specifications*. Stromberg-Carlson Corporation Document No. 9500209 (October 1966)
15. *S-C 4060 Stored Program Recording System. Software Description and Specifications*. Stromberg-Carlson Corporation Document No. 9500236 (April 1967)
16. *Electronic Composing System*. (U. S. Government Printing Office, Washington, D. C. 1966)
17. *A Course of Modern Analysis*. E. T. Whittaker and G. N. Watson (Cambridge University Press, London, 1952)
18. *Webster's New International Dictionary. Second Edition*. (G. and C. Merriam Company, Springfield, Mass., 1959) p. 75, p. 2750, p. 3001.
19. *Specimens of Type Faces*. (U. S. Government Printing Office, Washington, D. C.)
20. *Specimen Book and Catalog*. (American Type Founders Company, Jersey City, N. J. 1923) p. 785
21. *The Design of Lettering*. E. Weiss (Pencil Points Press, Inc., New York, 1932)

22. *The Alphabet and Elements of Lettering.* F. W. Goudy (University of California Press, 1942)
23. *Alphabets, Ancient and Modern.* J. B. Russell (Padell Book Co., New York, 1945)
24. *Lettering from A to Z.* C. P. Hornung (Wm. Penn Publishing Corporation, New York, 1954)
25. *Treasury of Alphabets and Lettering.* J. Tschichold (Reinhold Publishing Corporation, New York, 1966)
26. *Japanese Grammar Self-Taught.* H. J. Weintz (E. Marlborough & Co., London, 1907)
27. *New Critical Japanese-English Dictionary.* (Tokyo Government Bookstore Publication, 1921)
28. *Japanese Conversation Grammar.* O. Vaccari and E. E. Vaccari (Vaccari's Language Institute, Tokyo, 1965)
29. *English-Japanese Conversation-Dictionary.* O. Vaccari and E. E. Vaccari (Vaccari's Language Institute, Tokyo, 1963)
30. *Pictorial Chinese-Japanese Characters.* O. Vaccari and E. E. Vaccari (Vaccari's Language Institute, Tokyo, 1964)
31. *A. B. C. Japanese-English Dictionary, Parts I and II.* O. Vaccari and E. E. Vaccari (Vaccari's Language Institute, Tokyo, 1952)
32. *The Modern Reader's Japanese-English Character Dictionary.* A. N. Nelson (Charles E. Tuttle Company, Rutland, Vermont, 1962)

33. *Sanseido's New Concise Japanese-English Dictionary.* (Japan Publications Trading Company, Rutland, Vermont, 1959)
34. *Kenkyusha's New English-Japanese Dictionary.* (Kenkyusha Limited, Tokyo, 1960)
35. *Encyclopaedic Dictionary of Physics, Volume 9. Multilingual Glossary.* (MacMillan Company, New York, 1964)
36. *Computer Typesetting.* M. P. Barnett (M. I. T. Press, Cambridge, Massachusetts, 1965)
37. *The Visual Perception of Size and Distance.* W. C. Gogel, Vision Research, Vol. 3, p. 101 (1963)

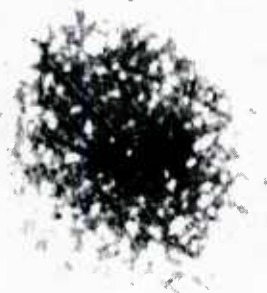


FIGURE 1.

Photomicrograph at 650 magnification of dot plotted by NORC
S-C 4010 Printer on 35 mm Recordak Dacomatic Safety Film.

APPENDIX A

DIGITALIZATION WITH DOTS

In each panel, the coordinates of each dot are plotted at enlarged scale on the left, the character and its number are plotted at normal scale in the upper right, and the digit pairs are listed at the right.

PART I

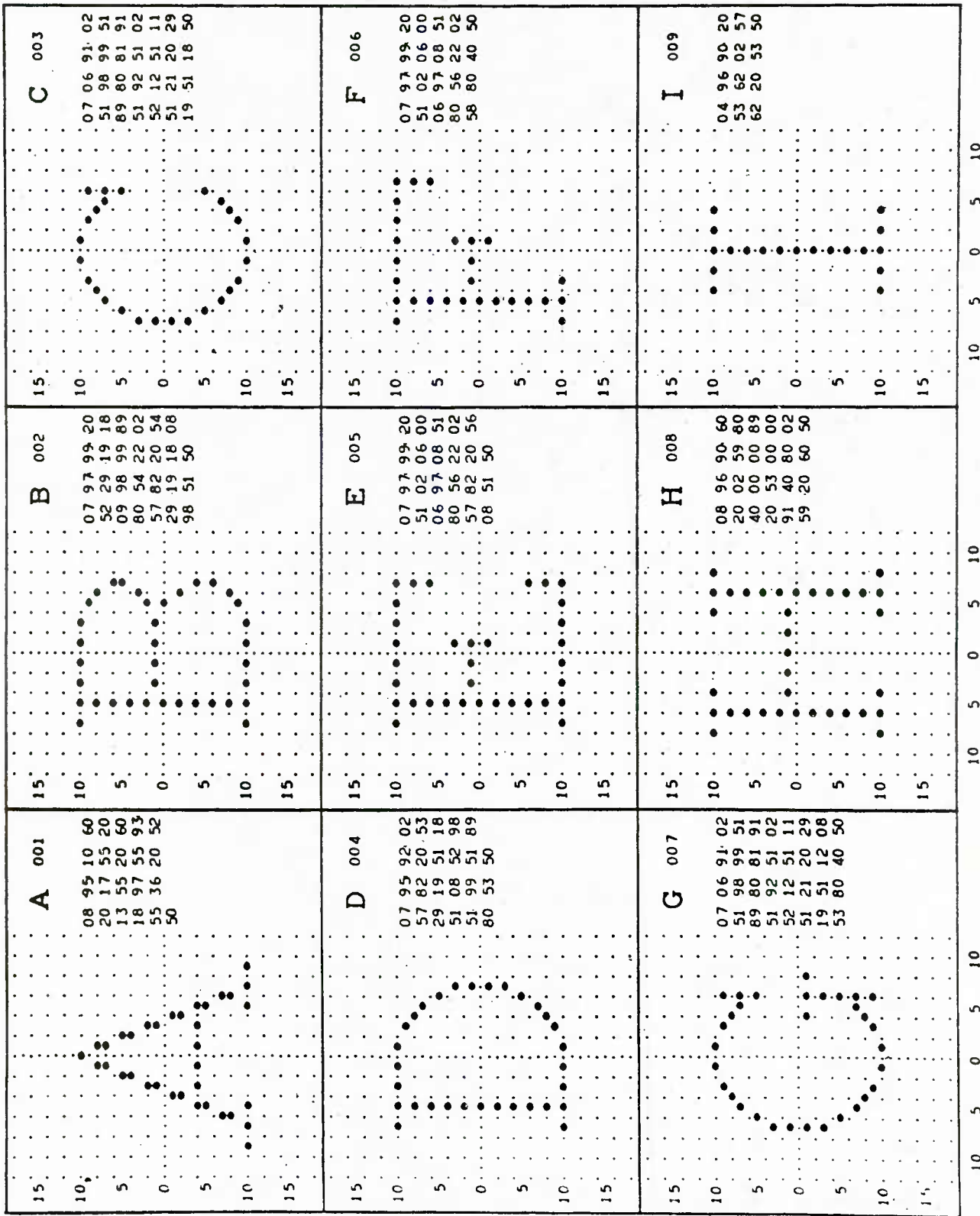
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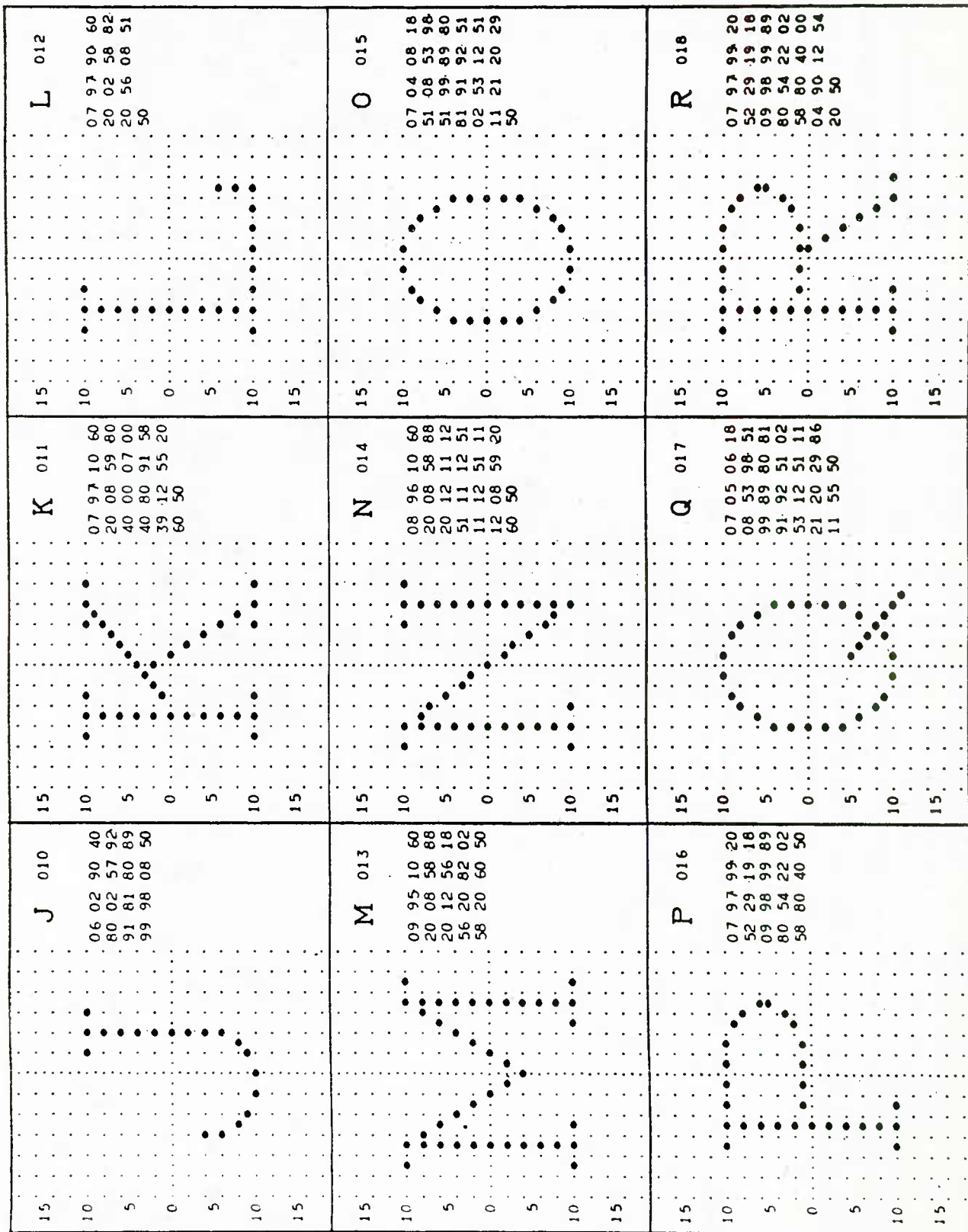
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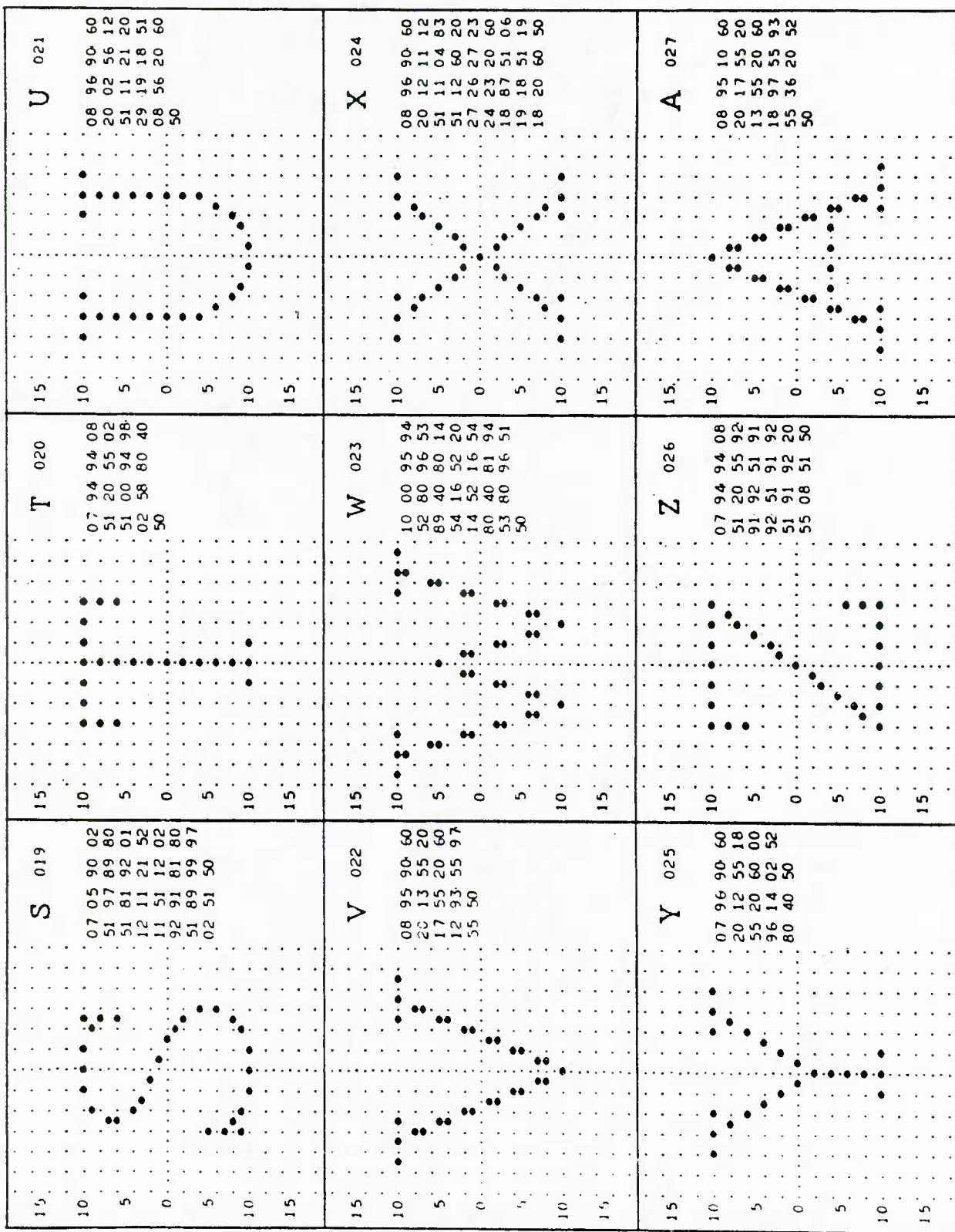
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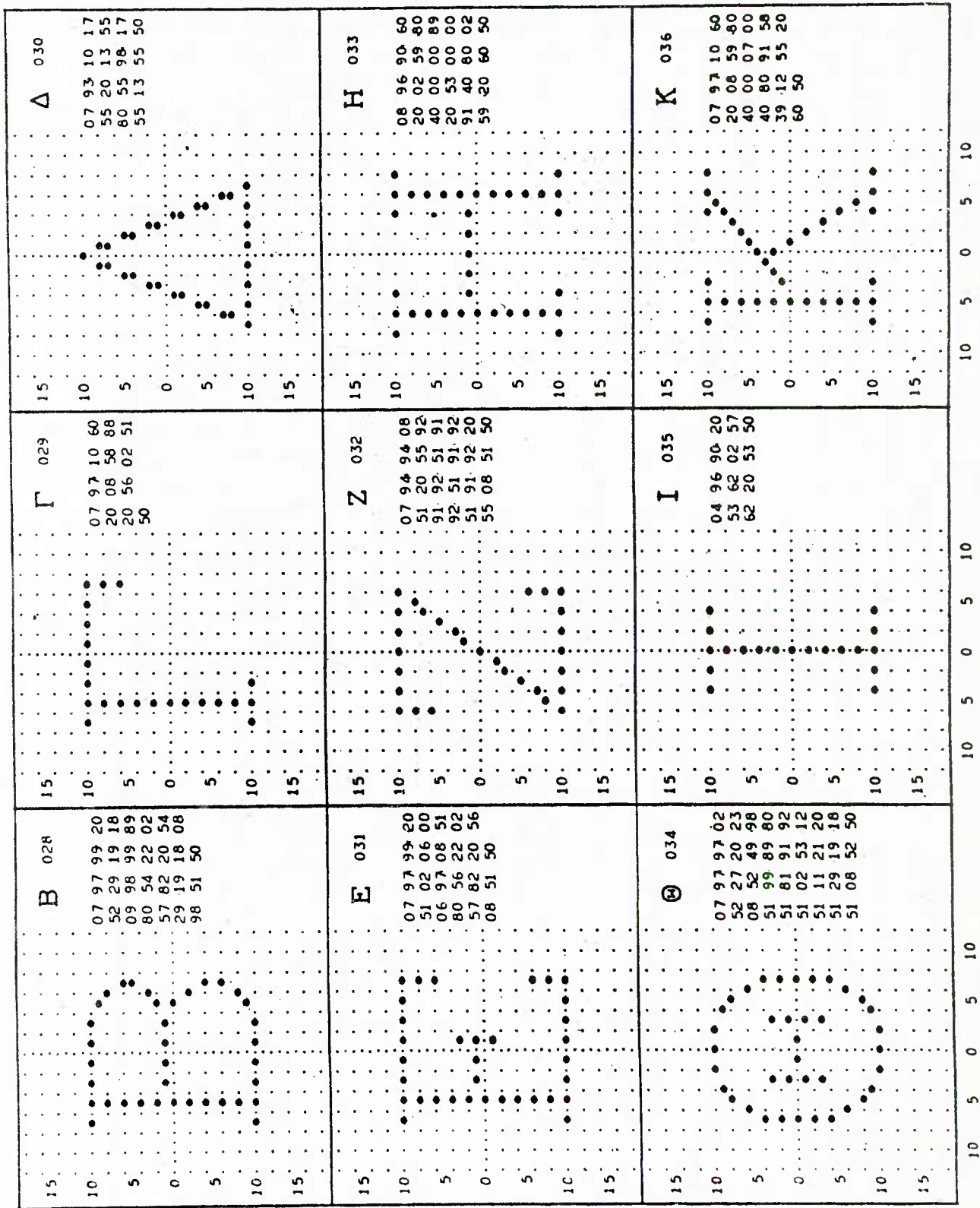
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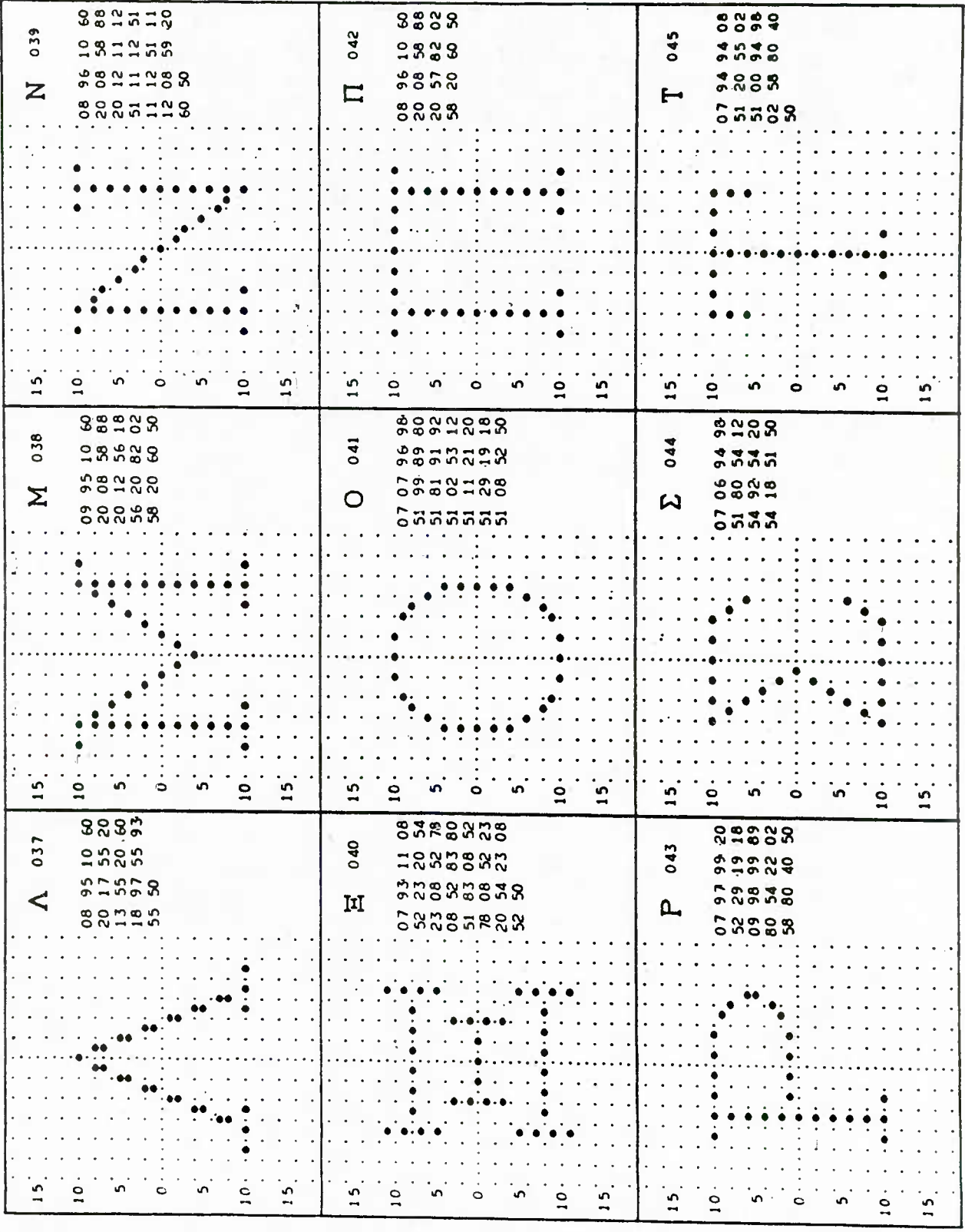
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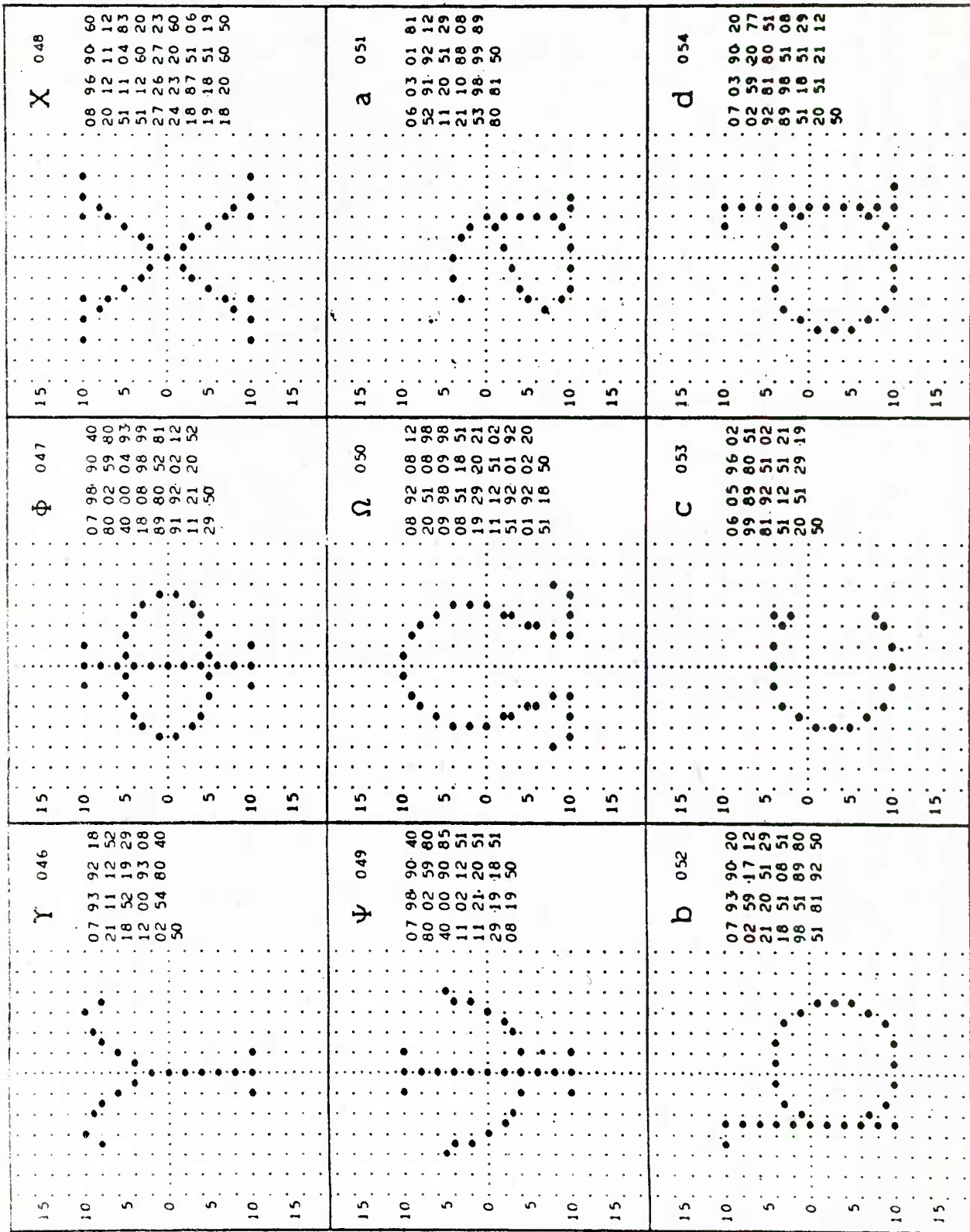




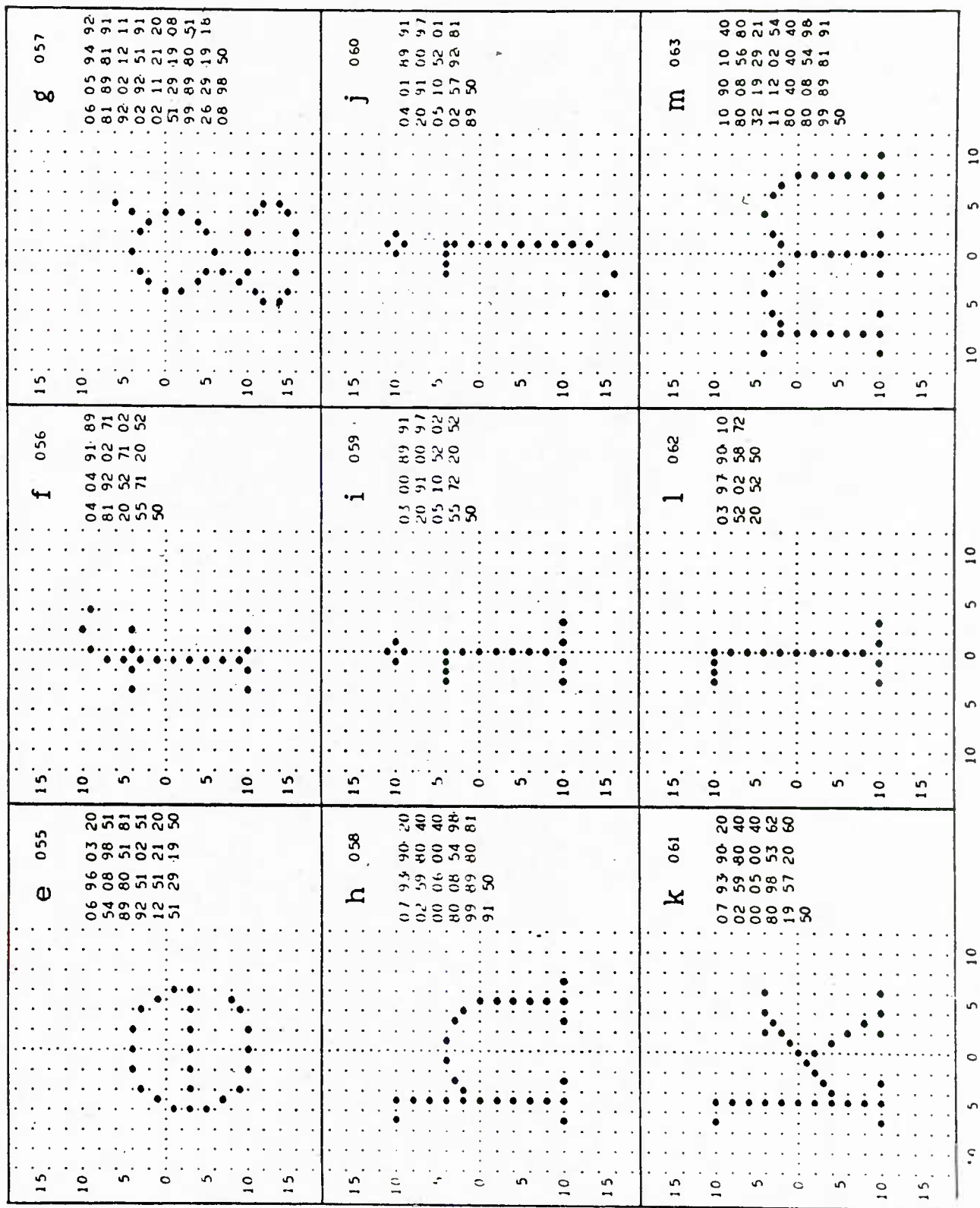


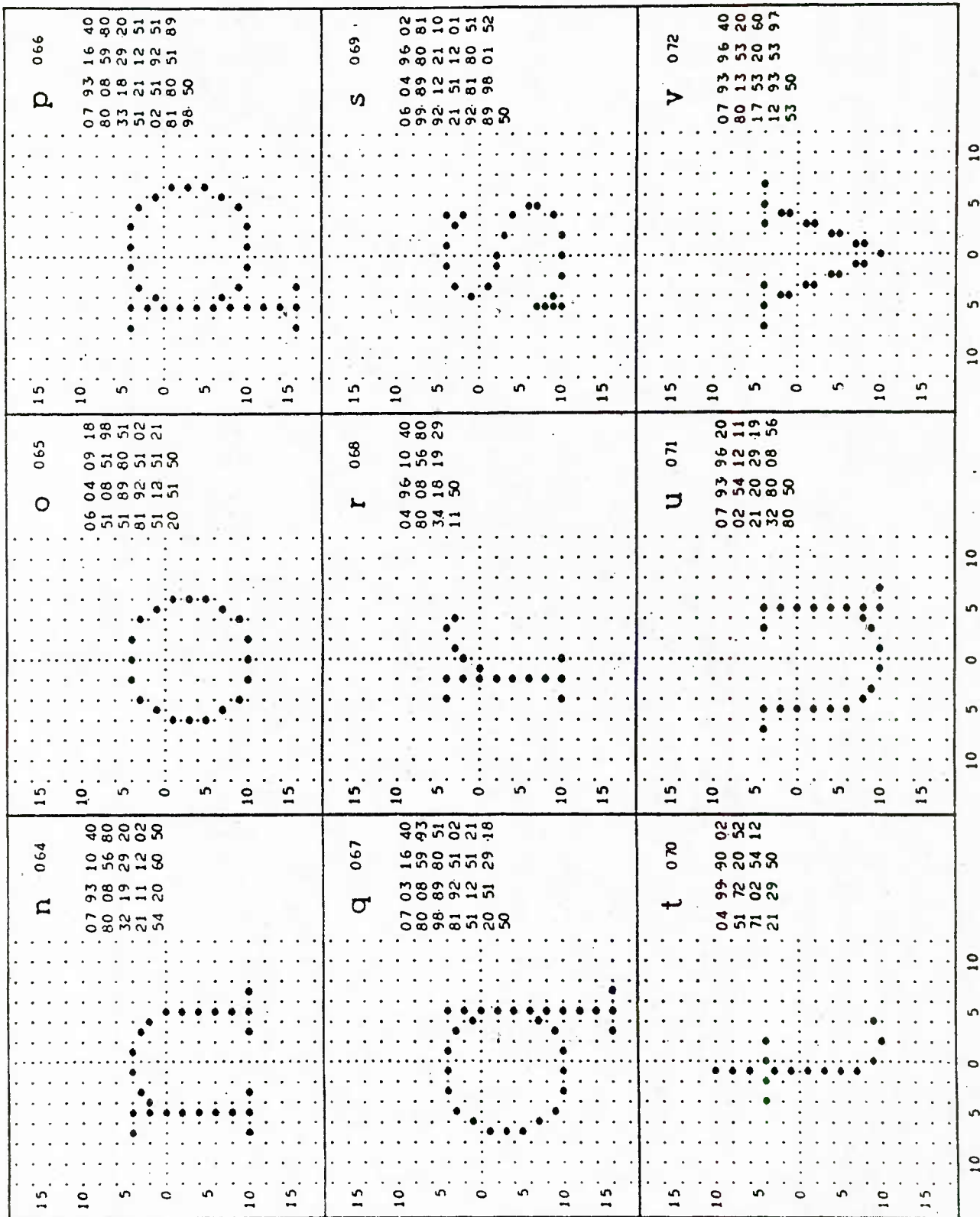


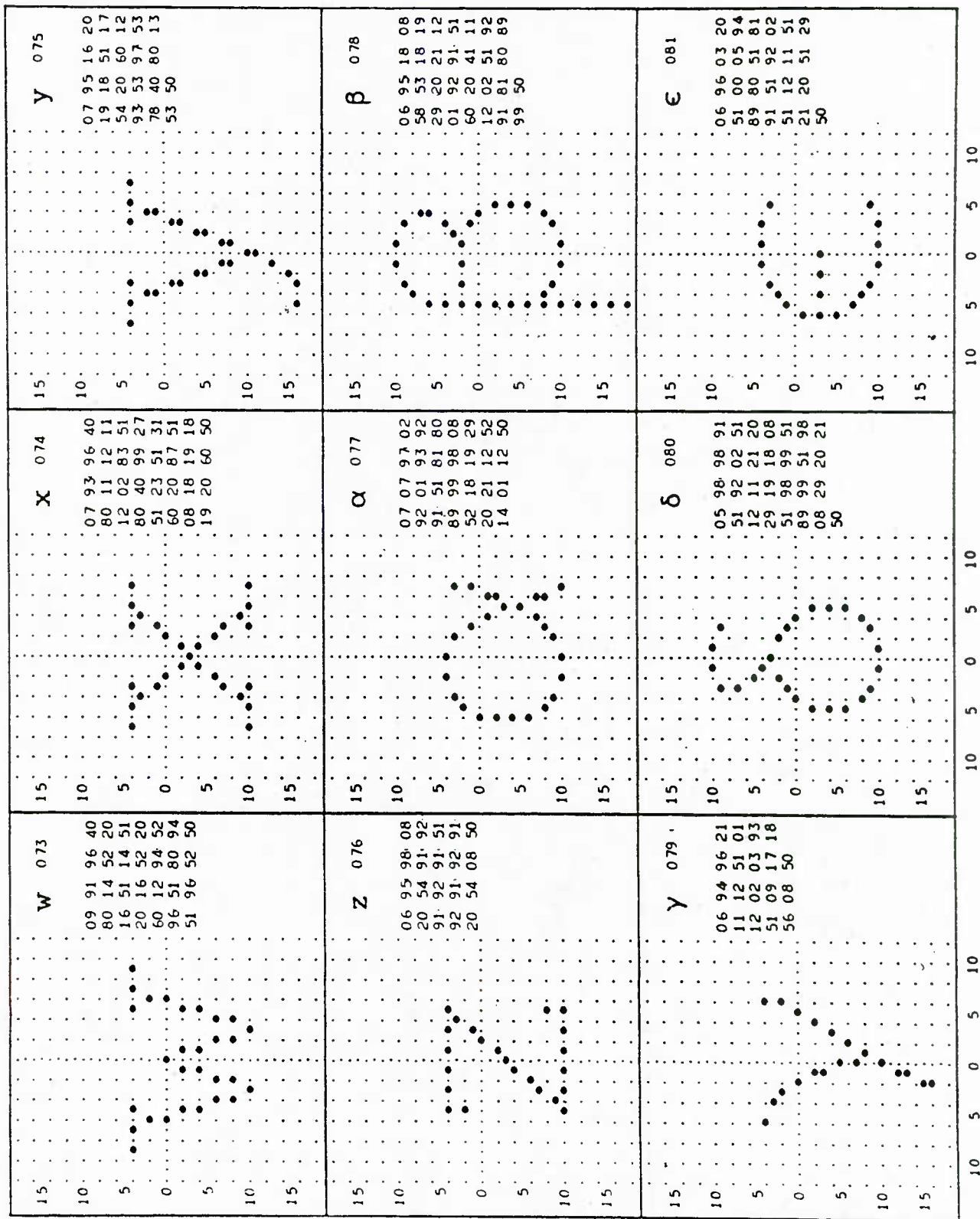


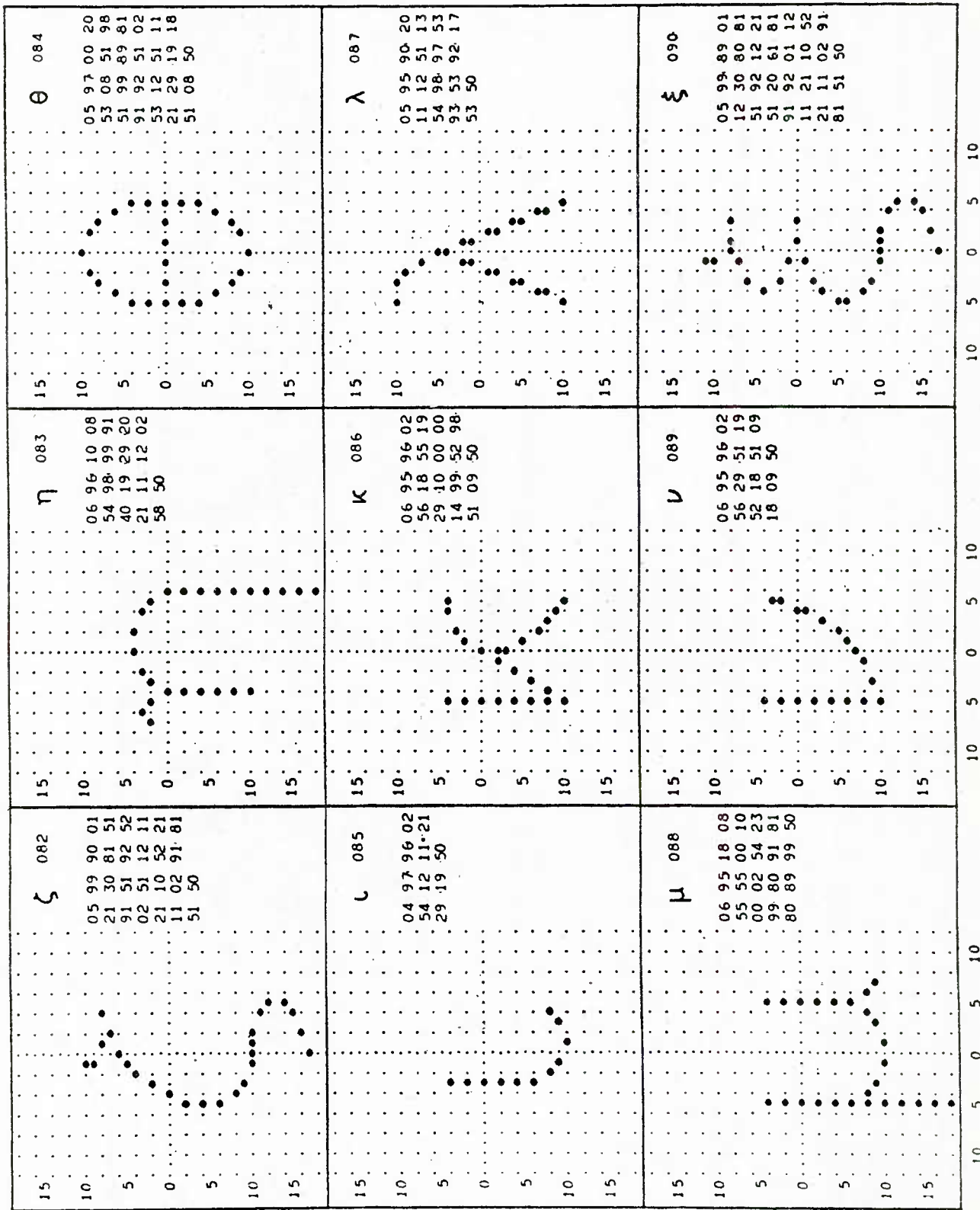


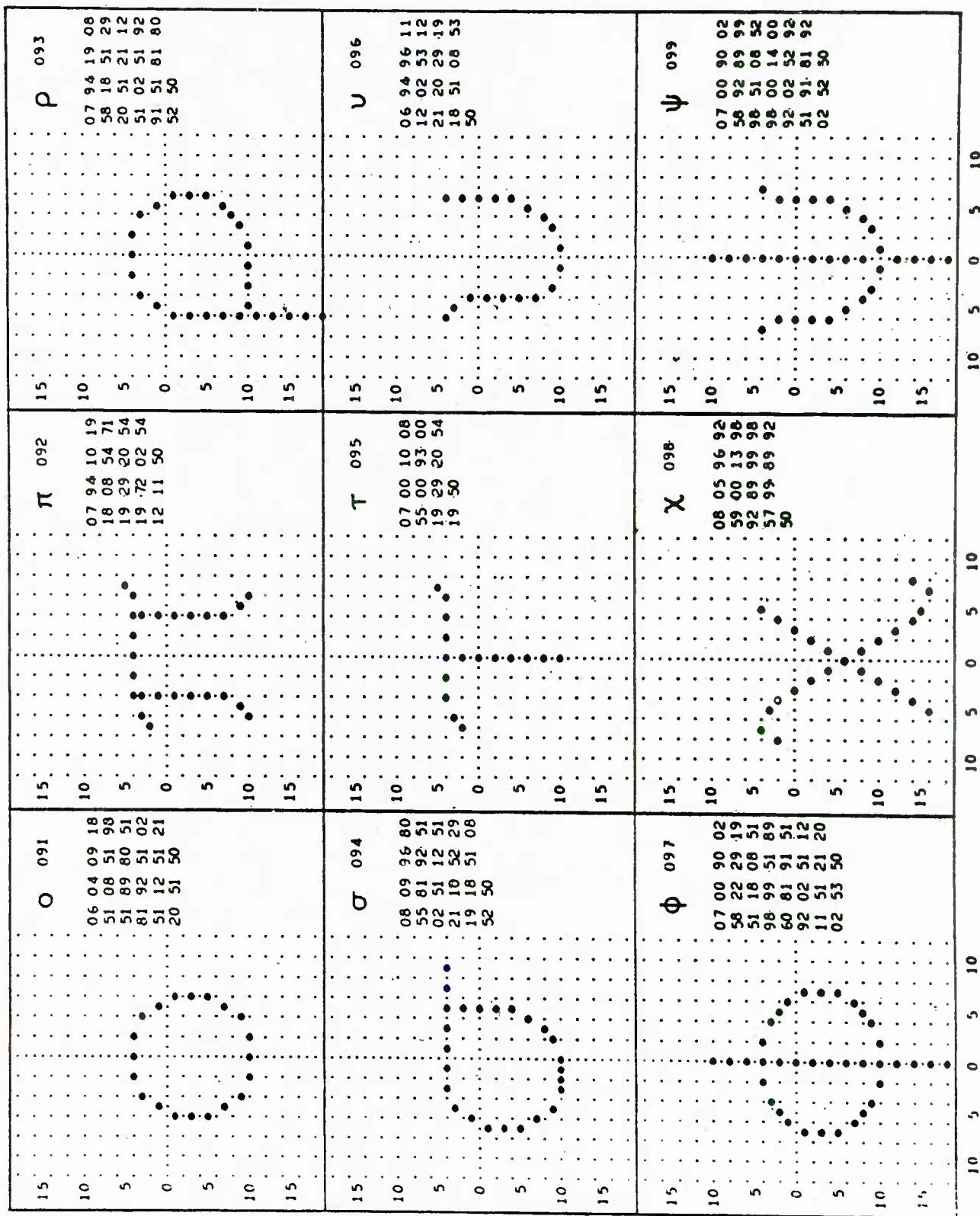
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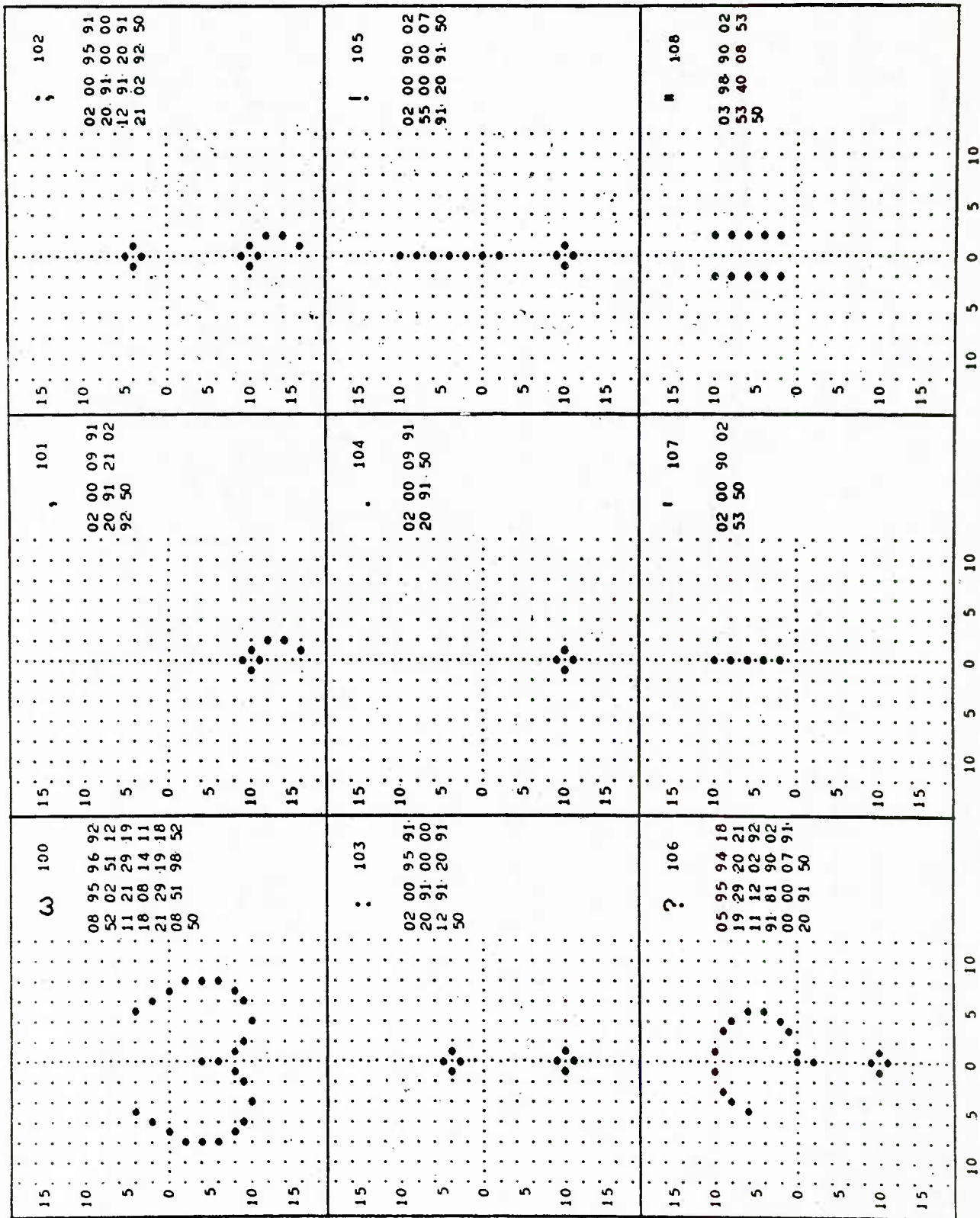


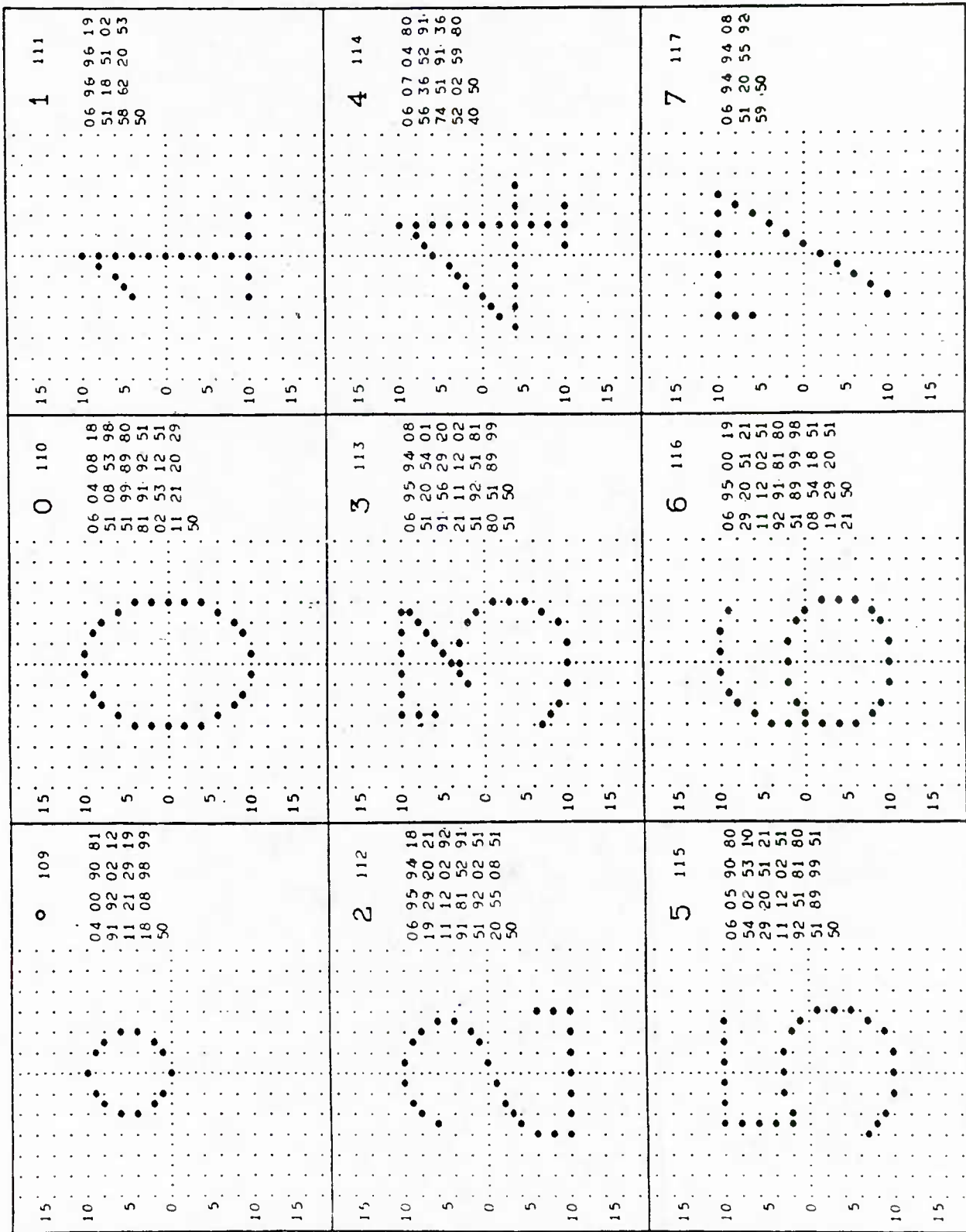




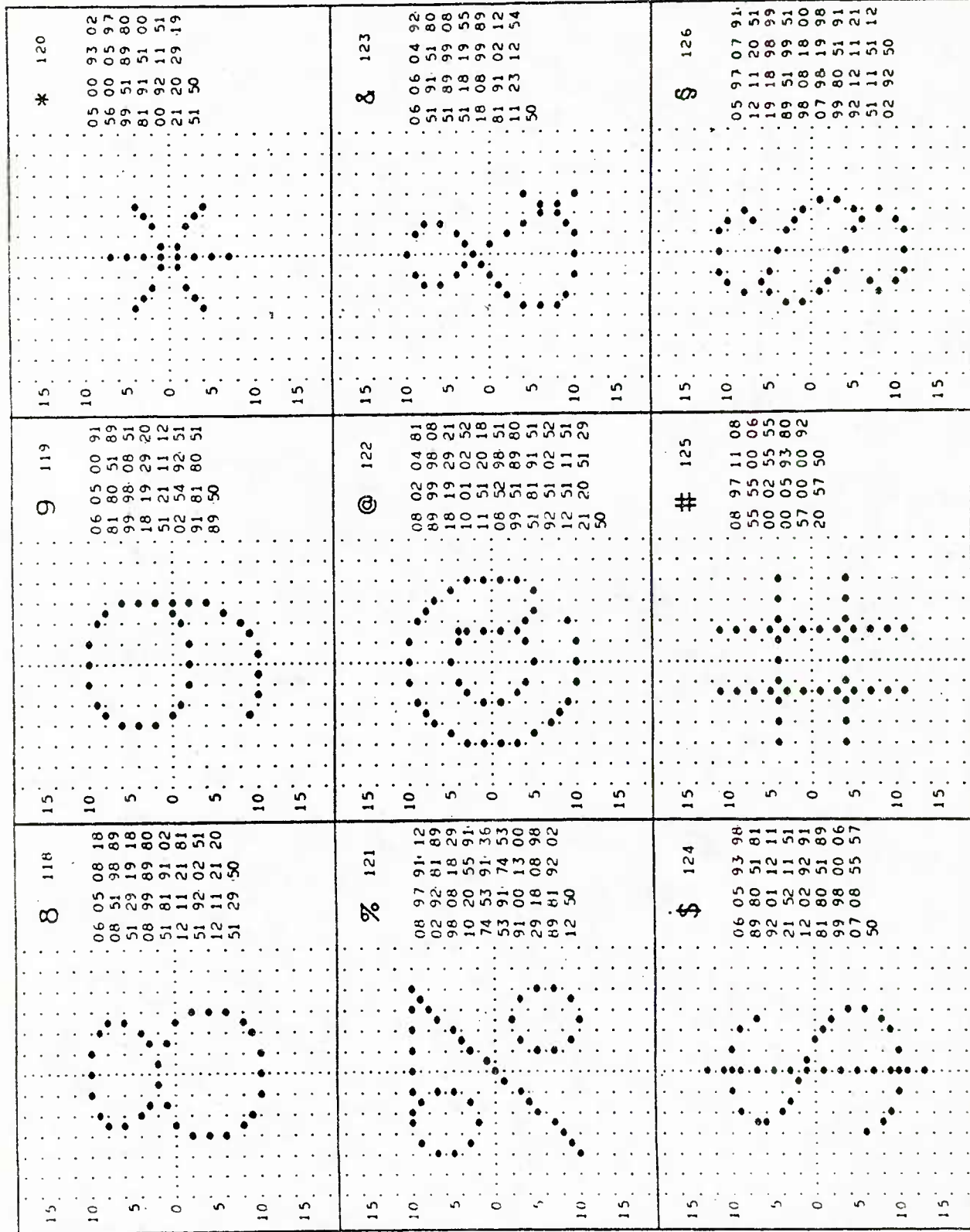


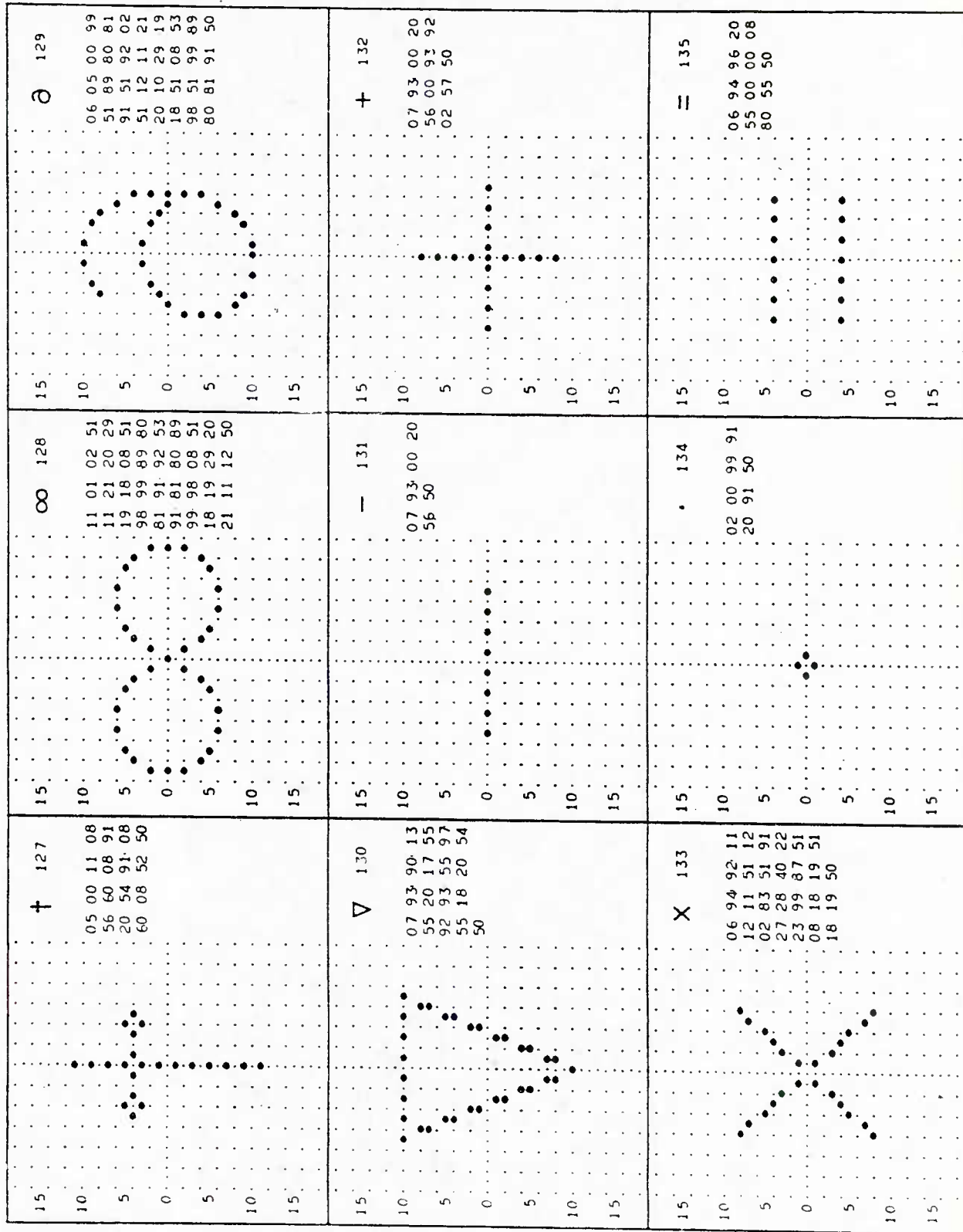




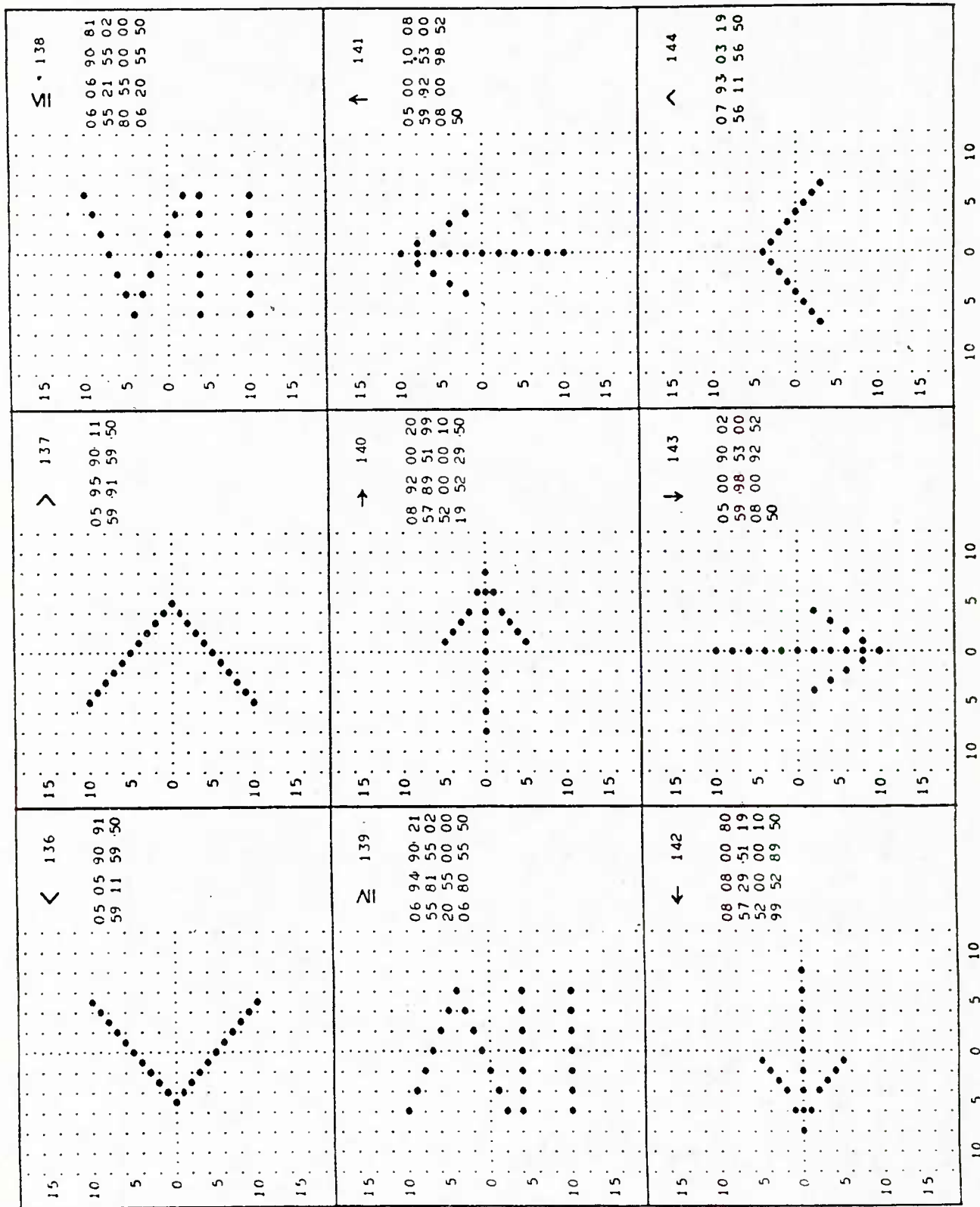


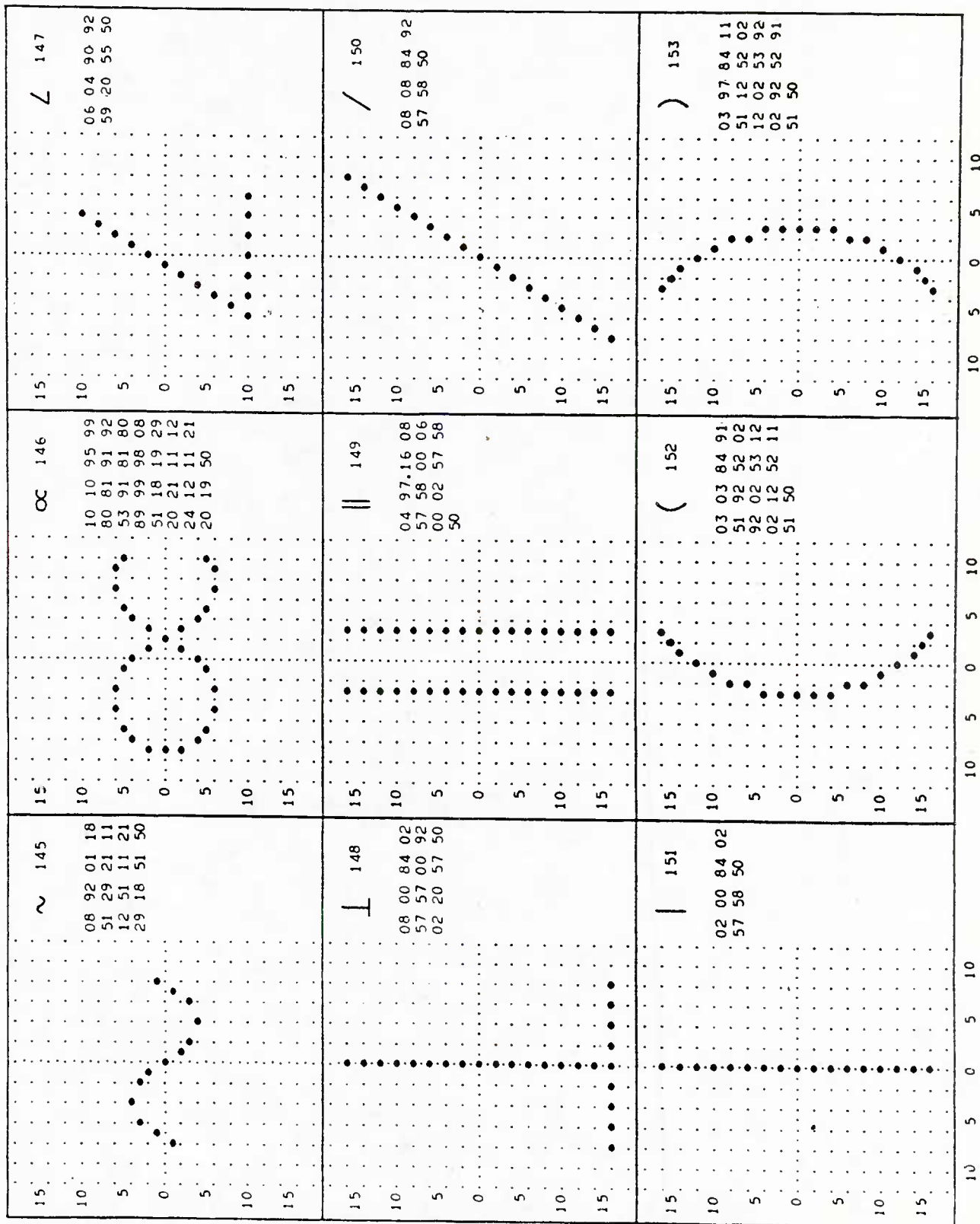
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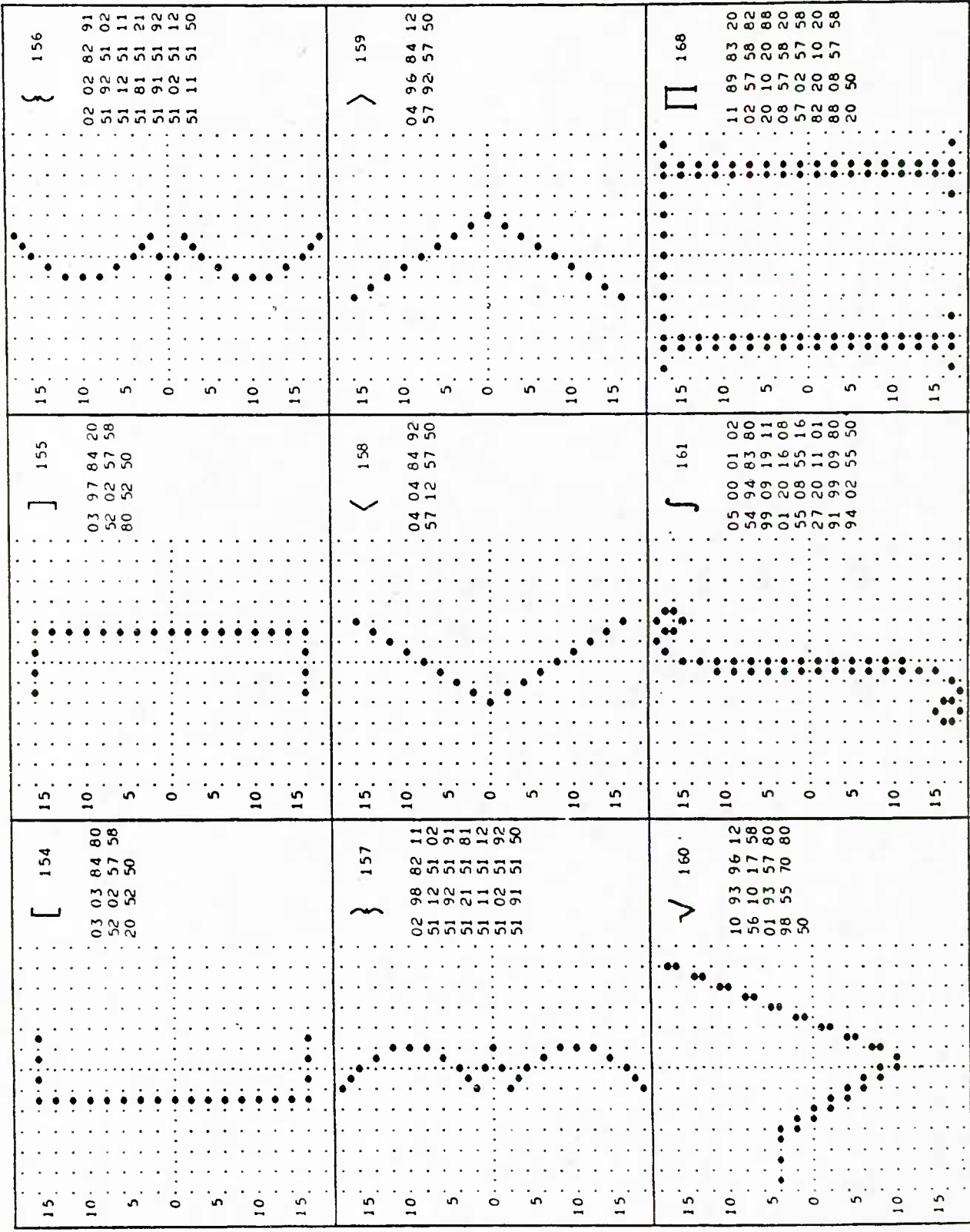


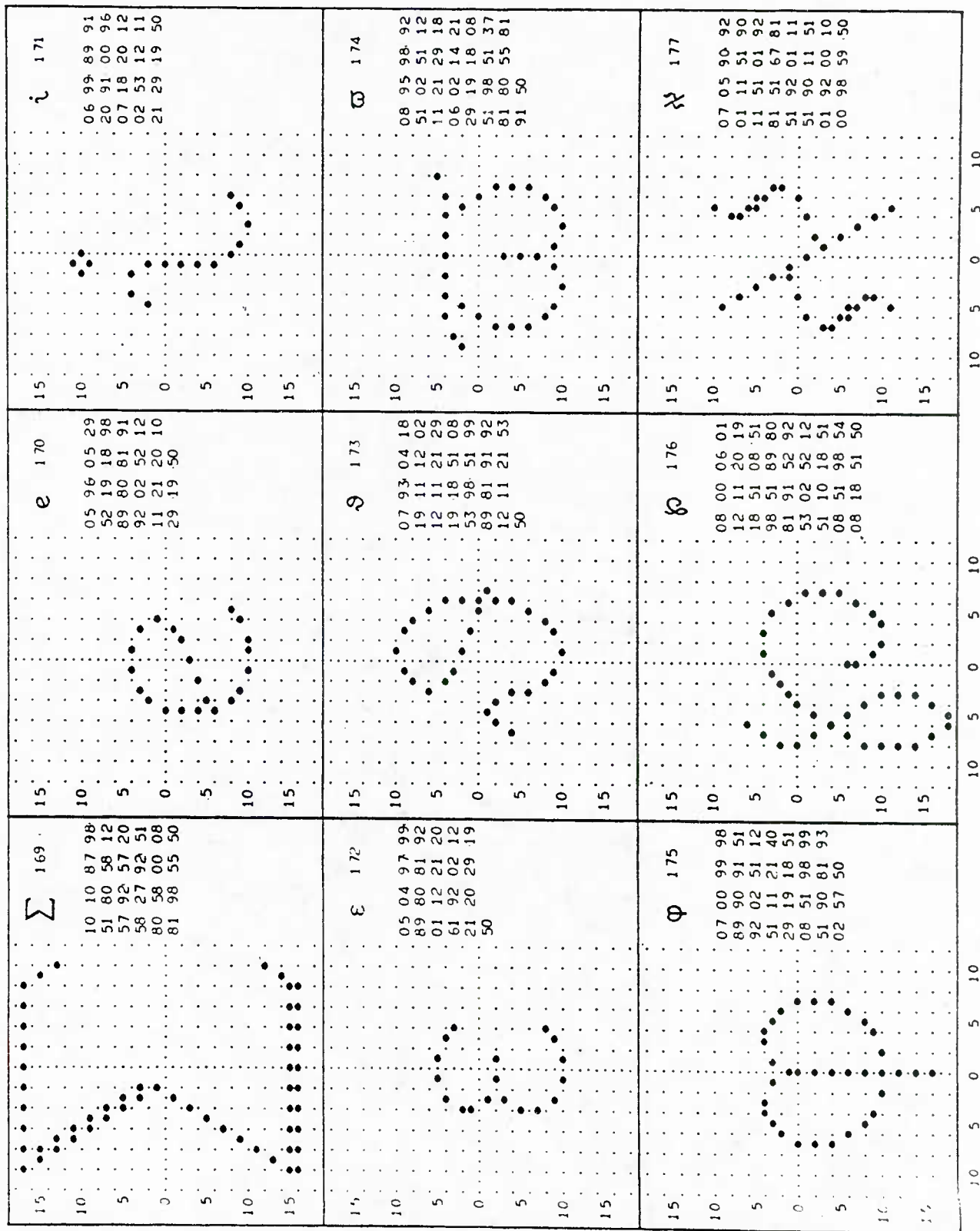


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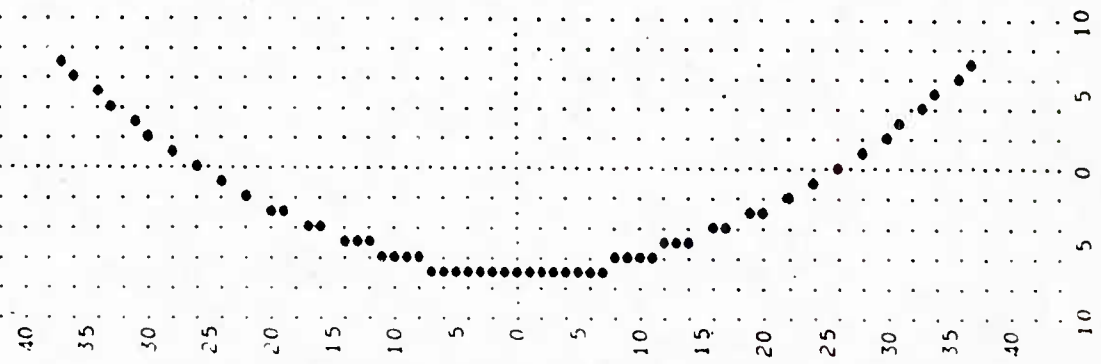






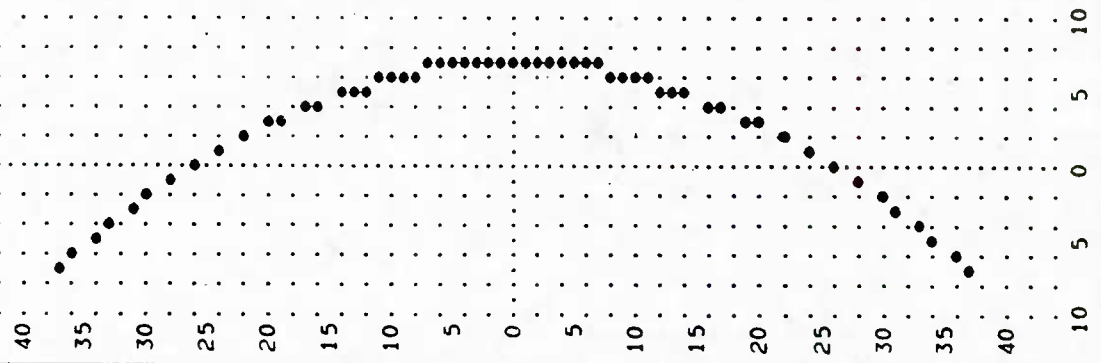
(162

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01 56 57 11
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01 12 54 23
51 11 87 51
50



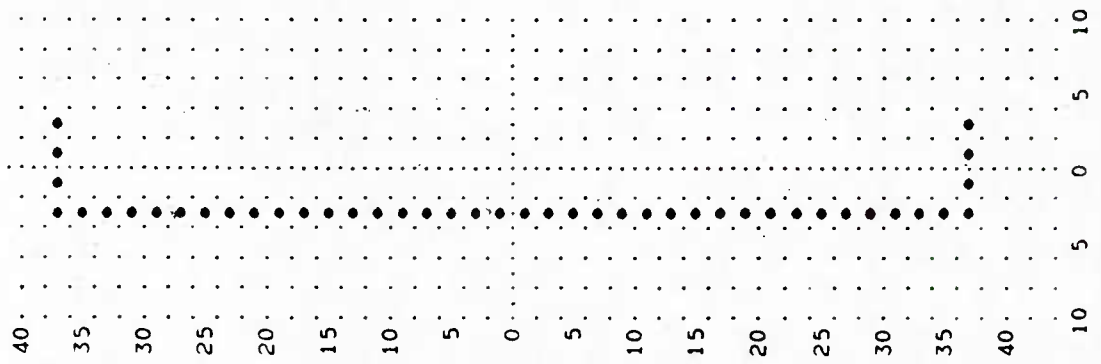
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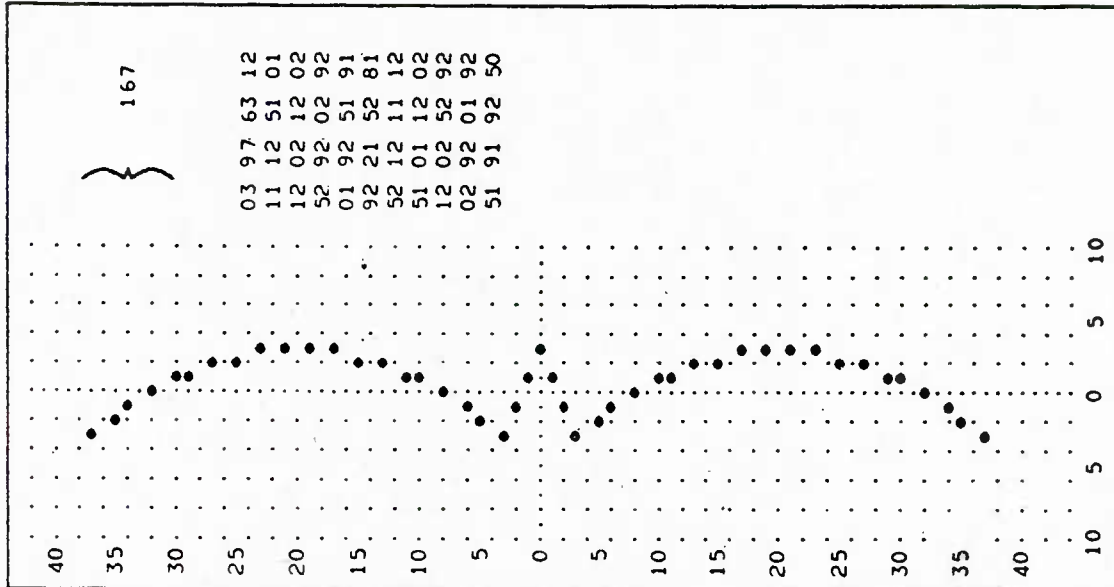
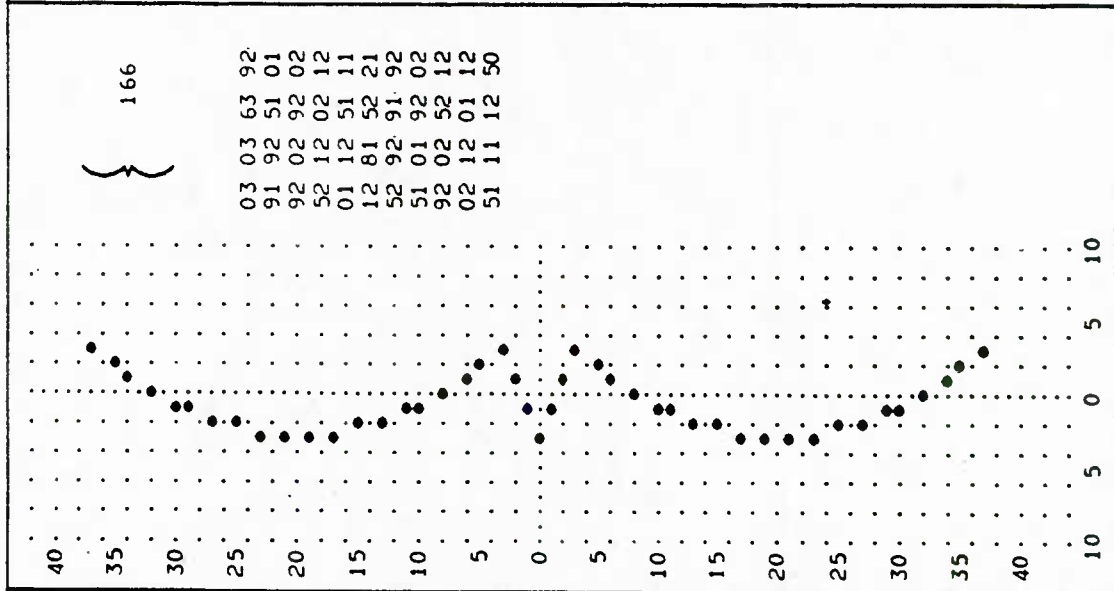
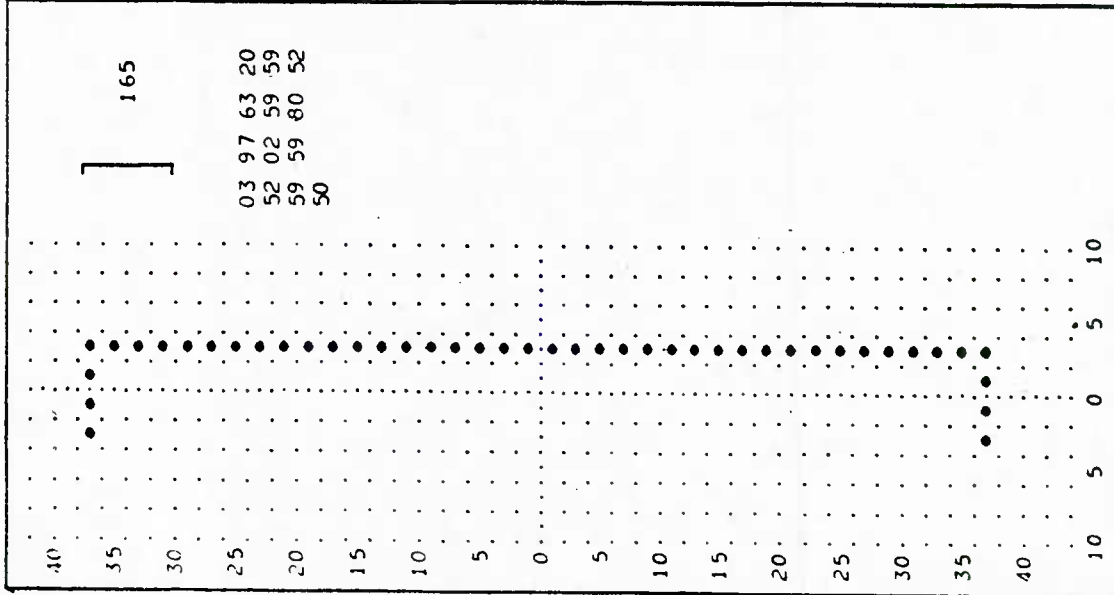
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[164

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52 02 59 59
59 59 20 52
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PART II

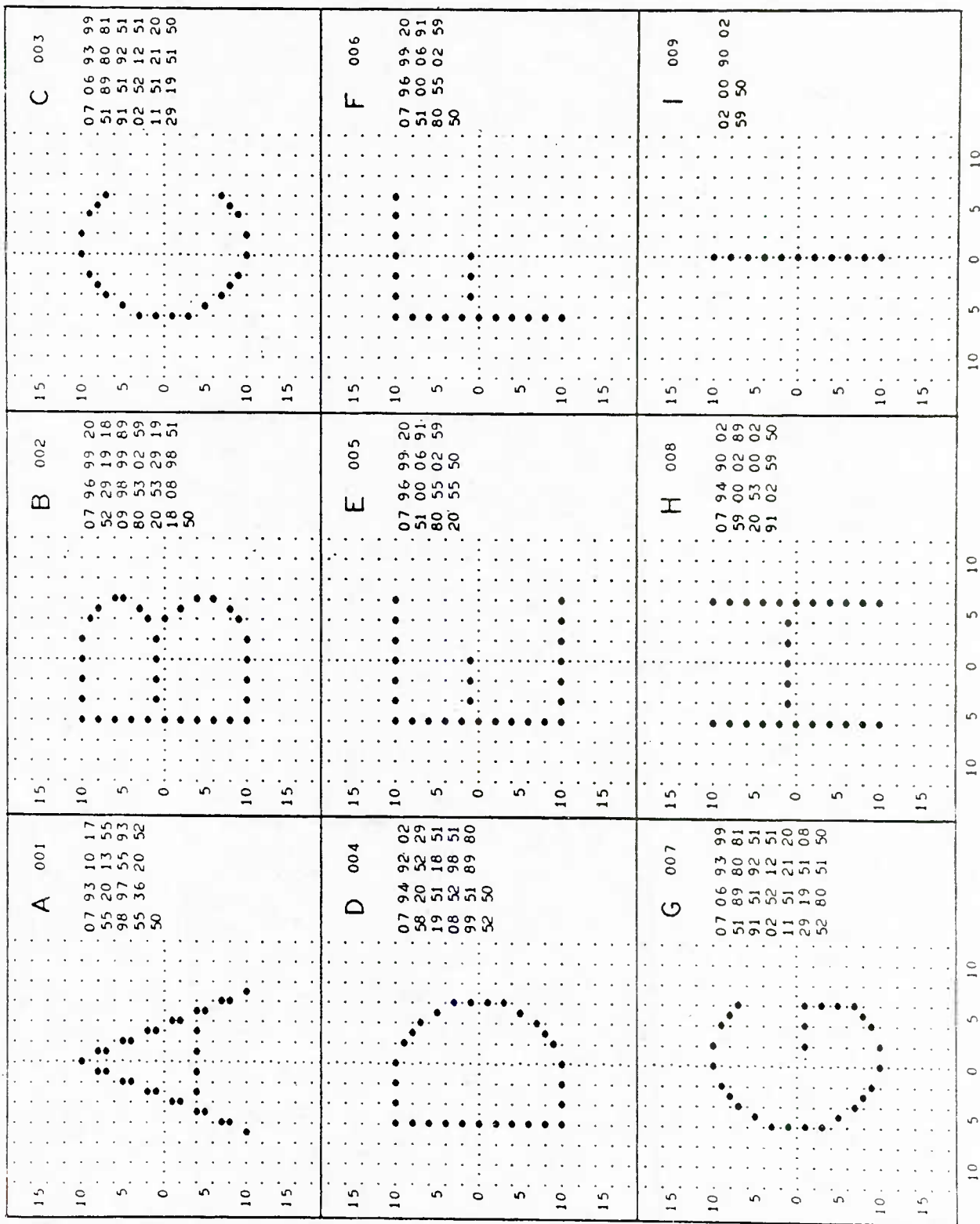
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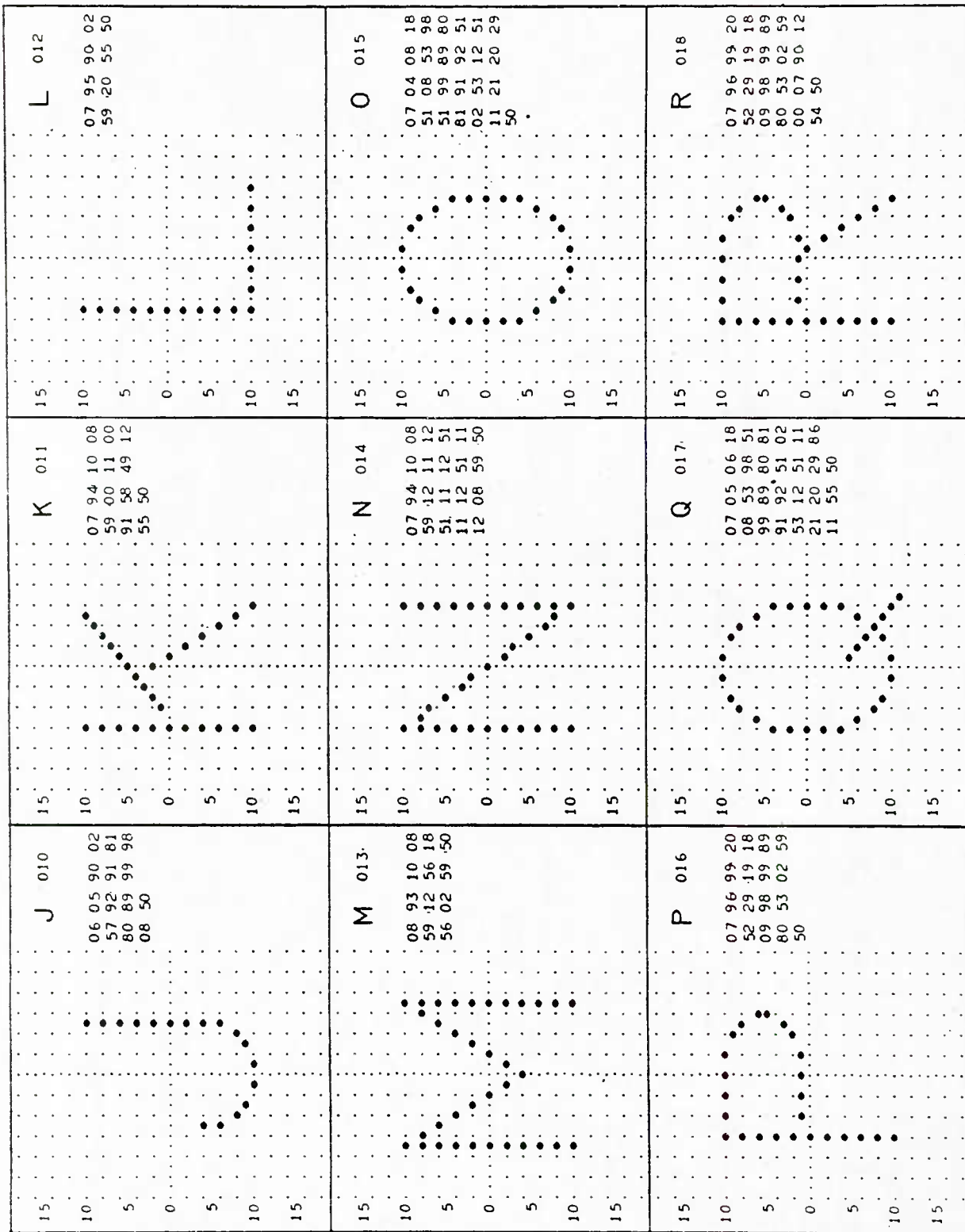
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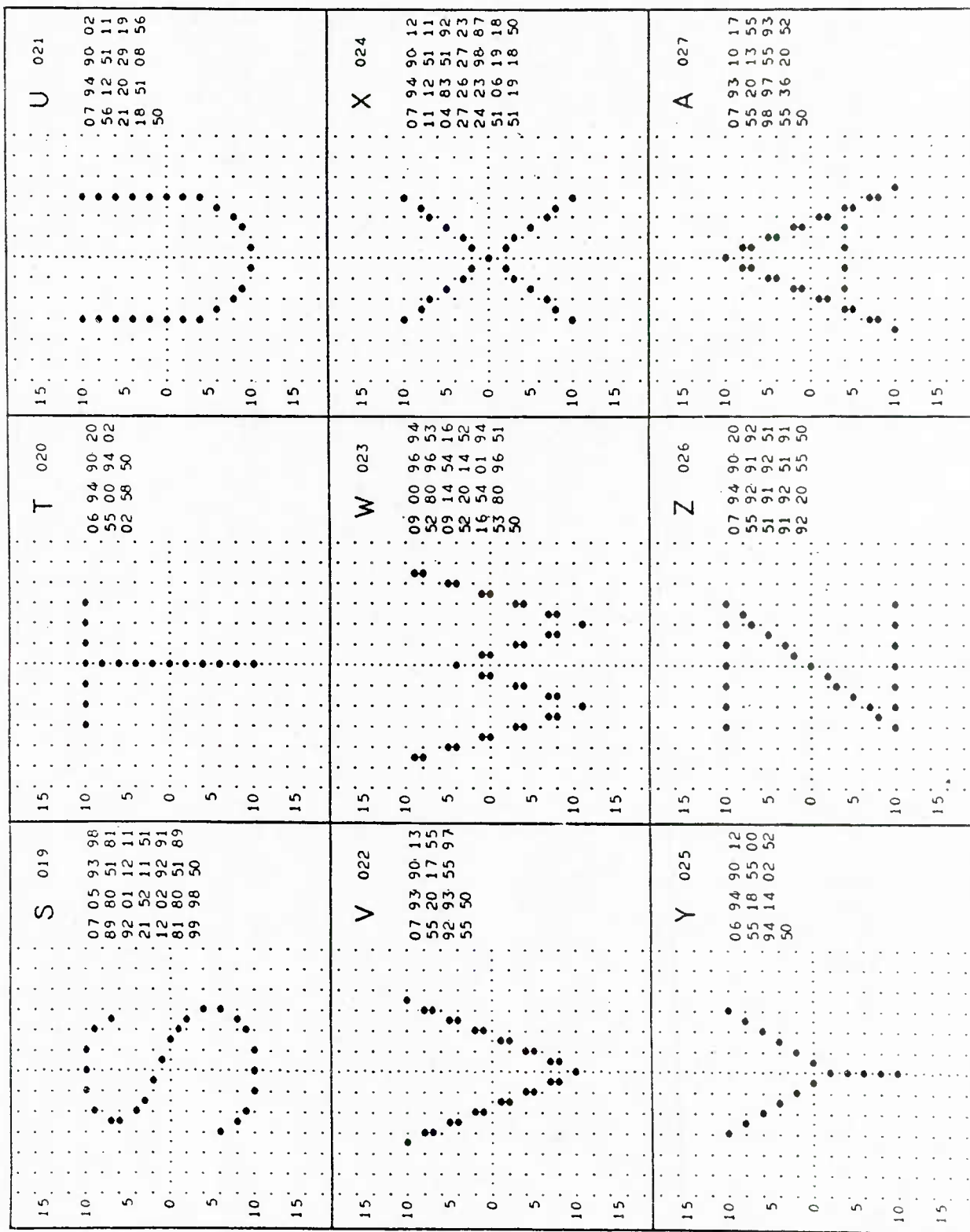
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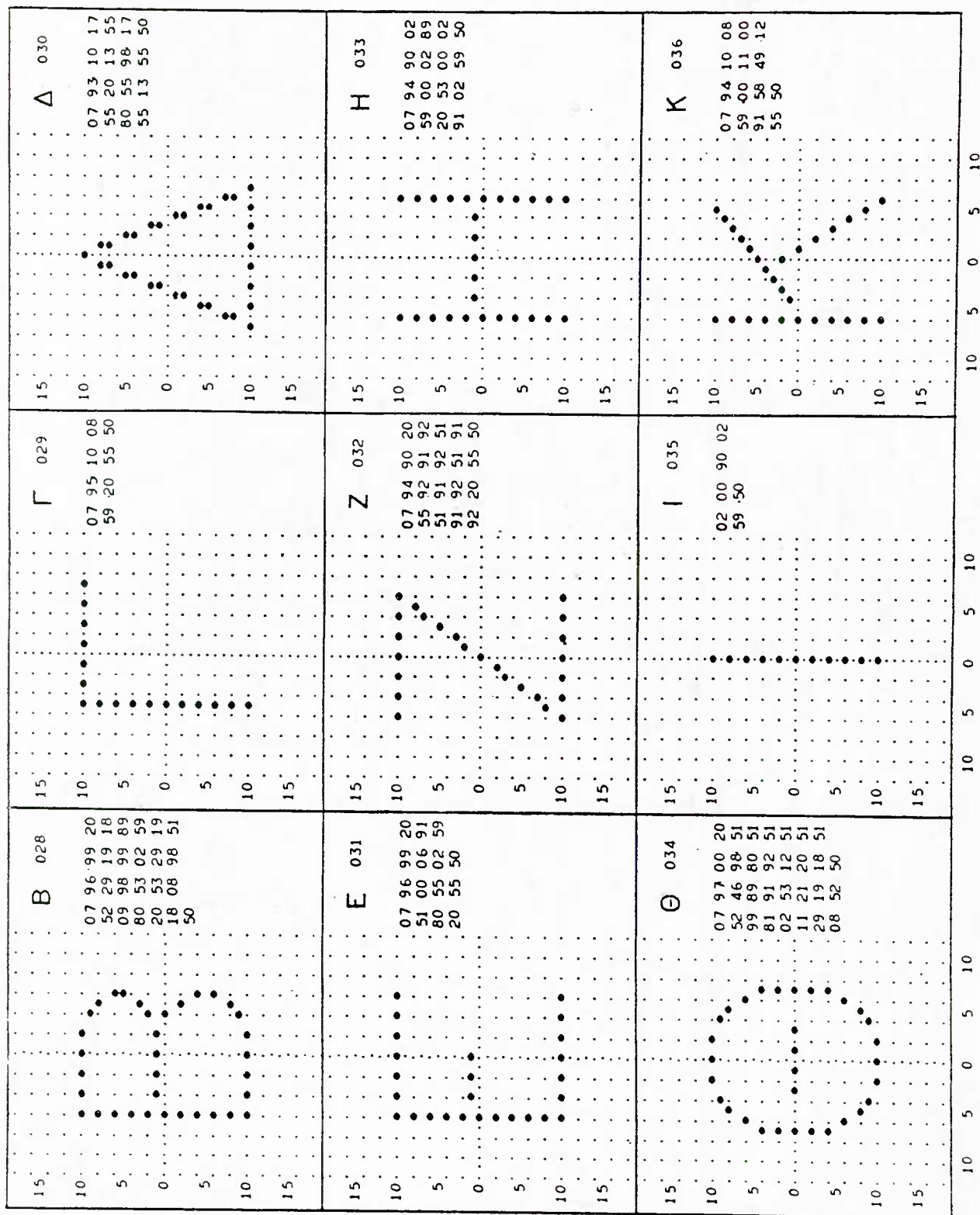
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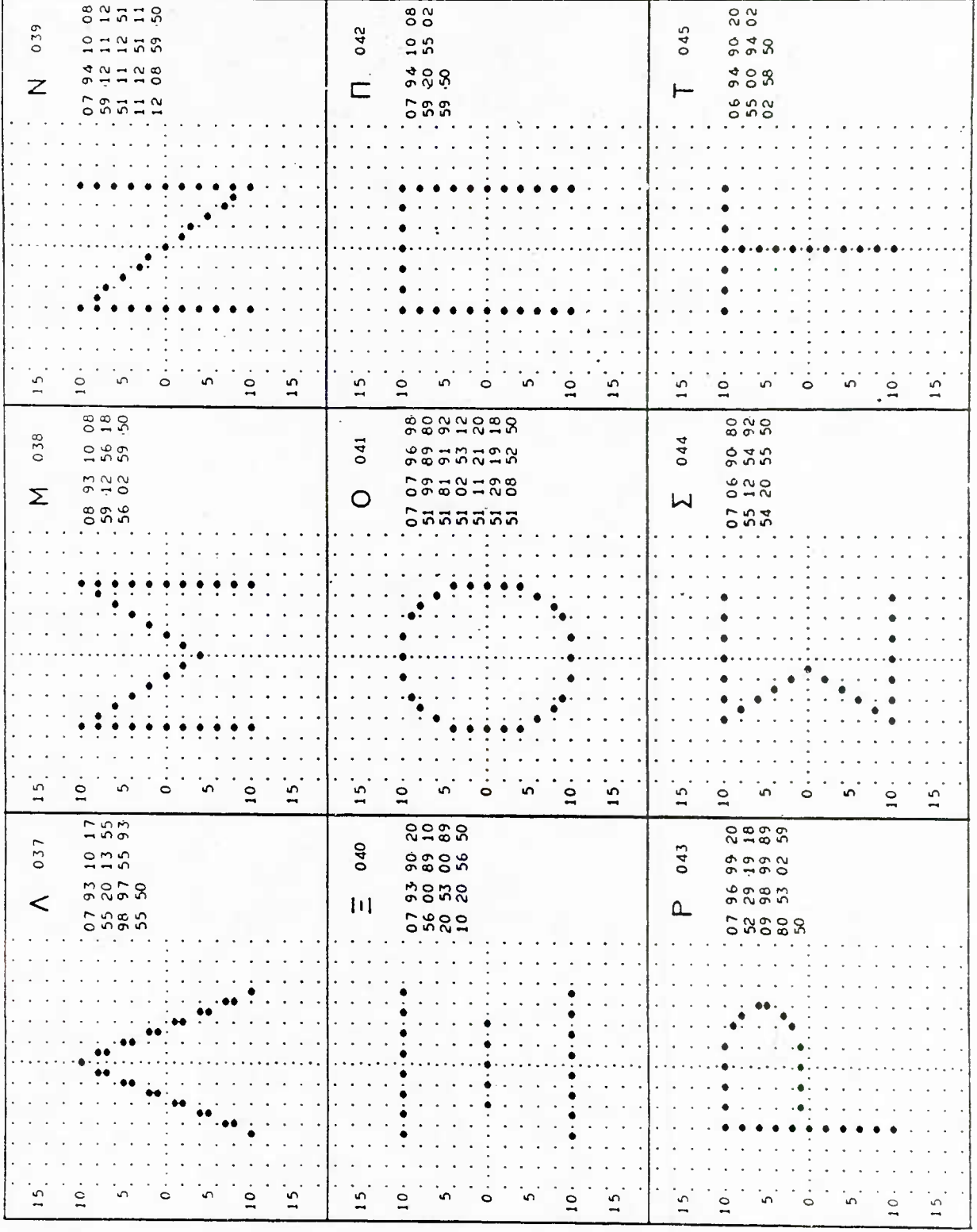
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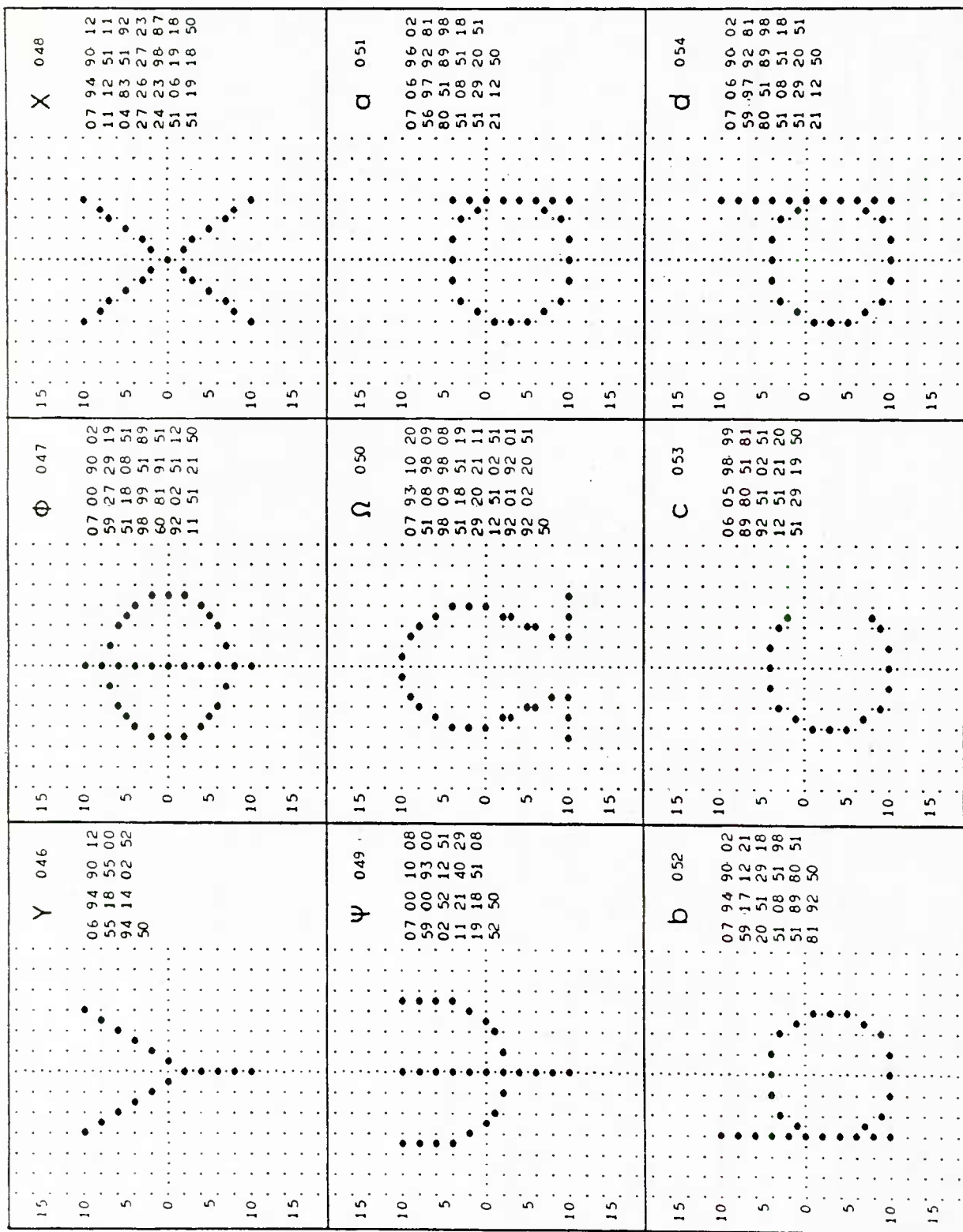


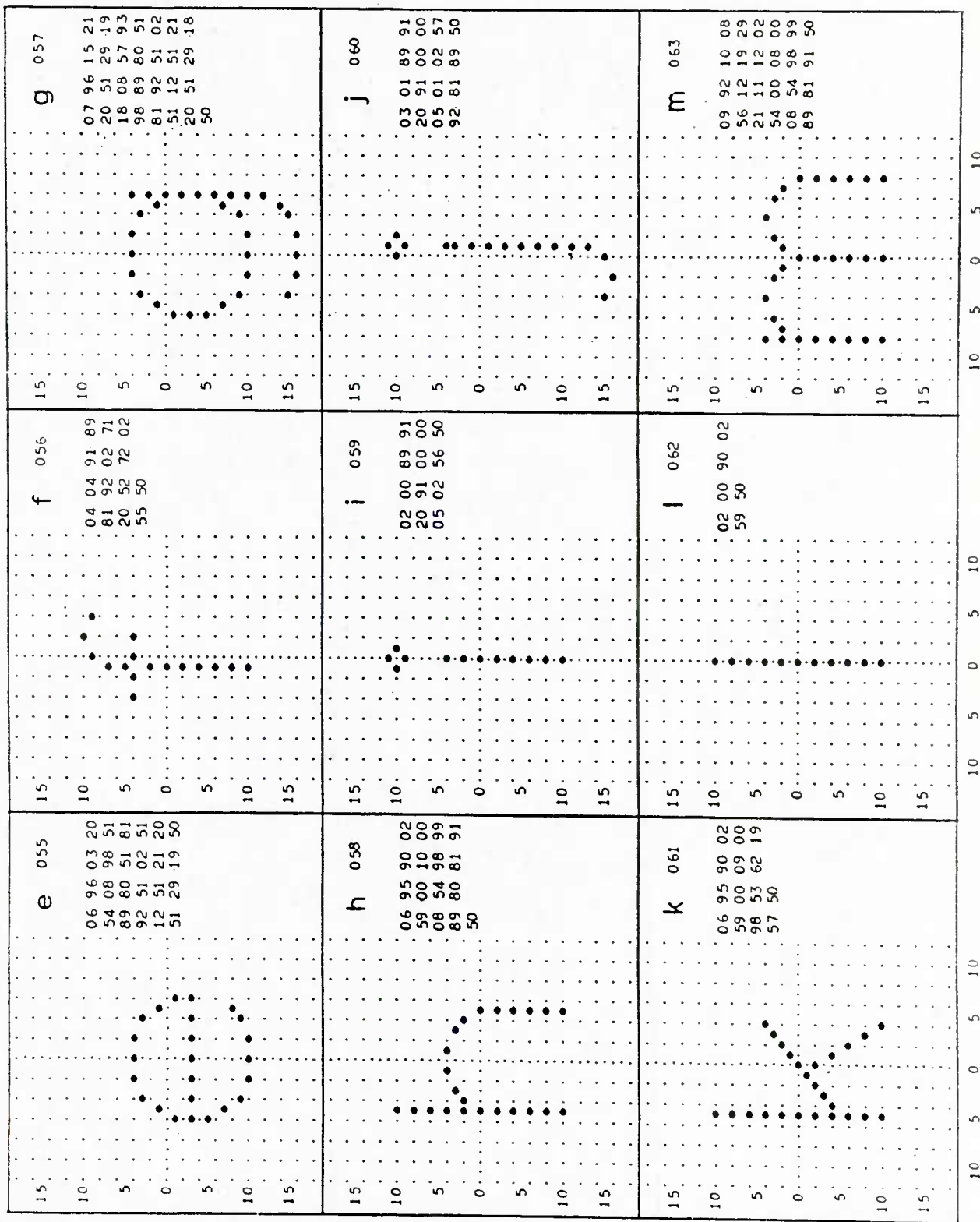




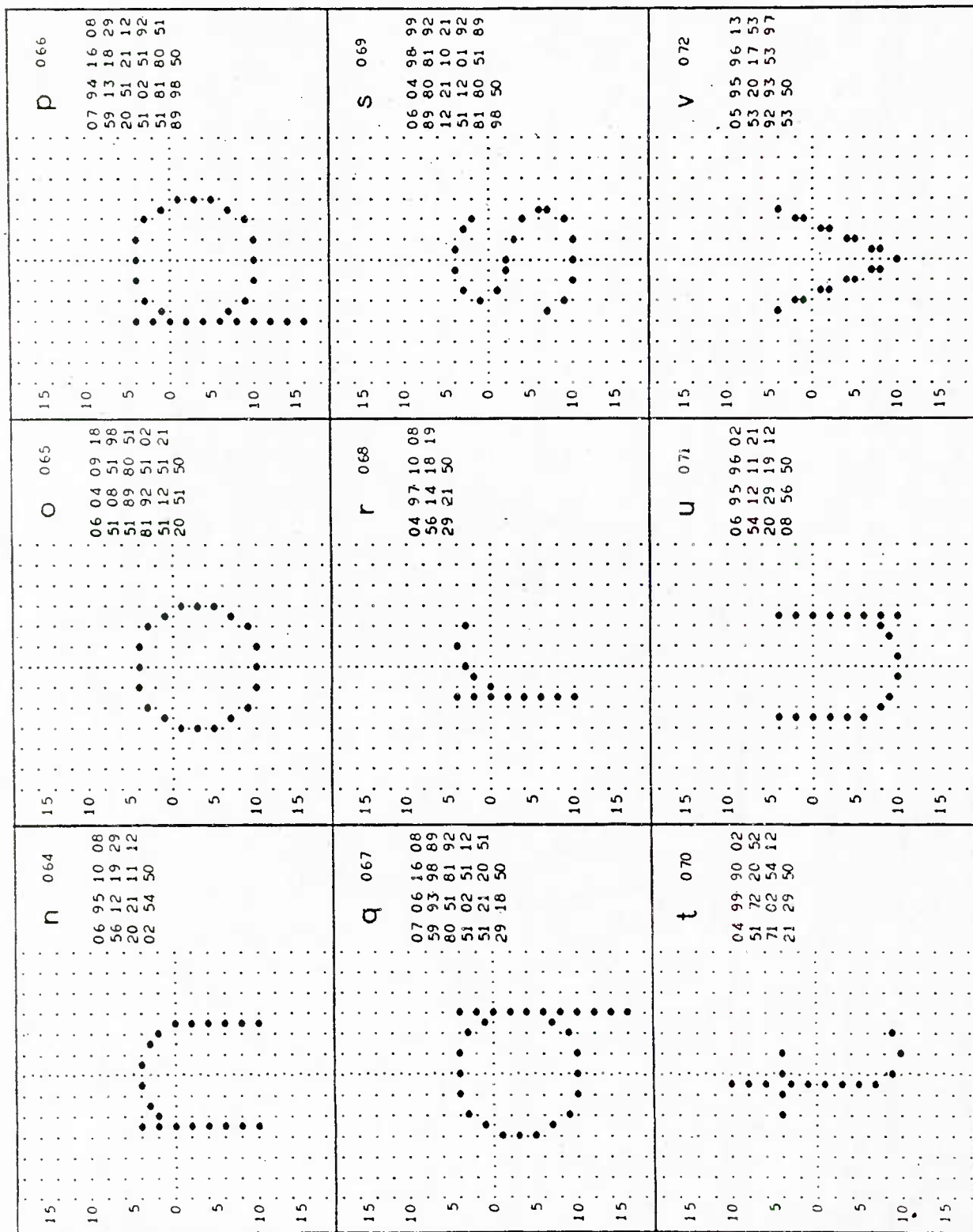




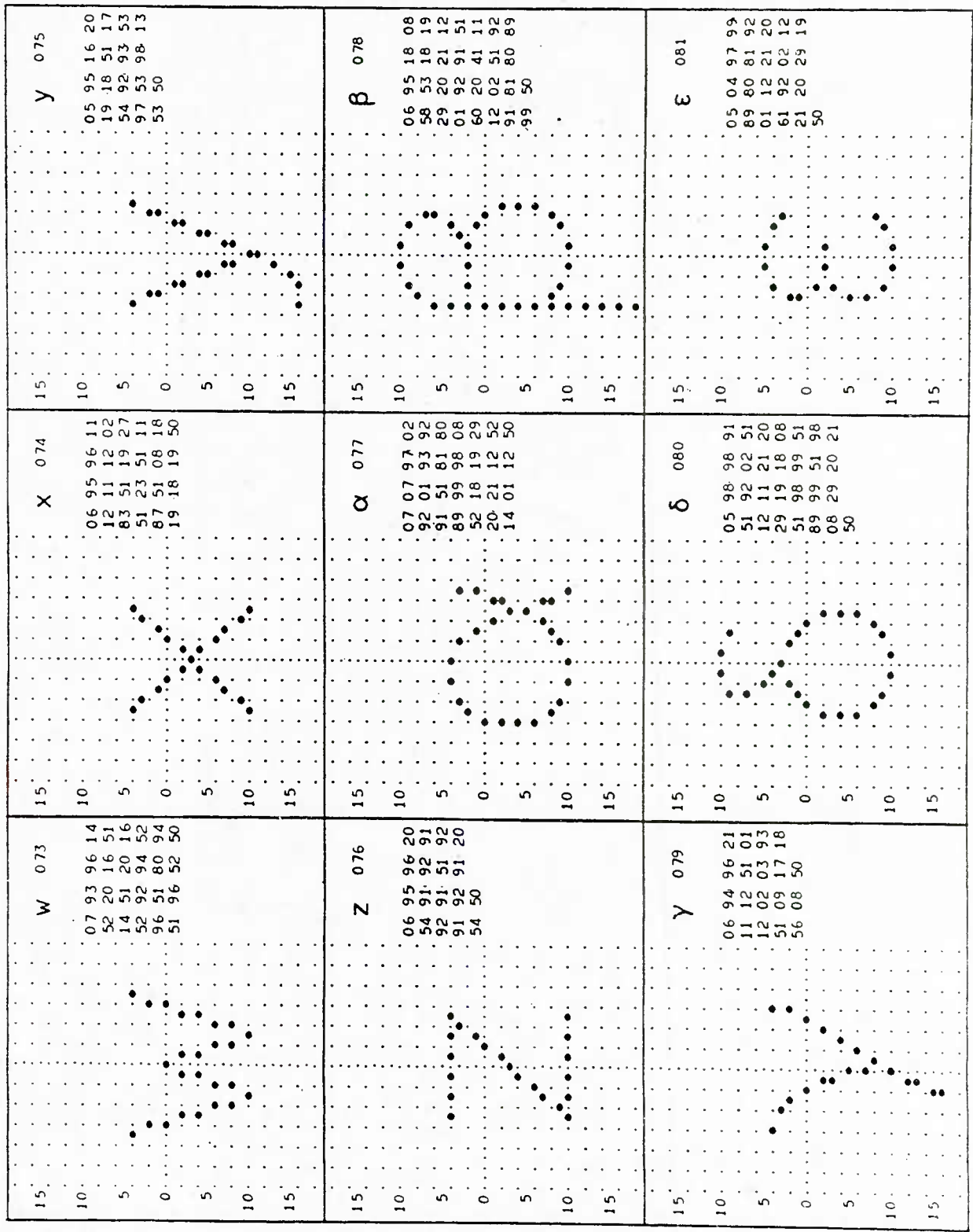


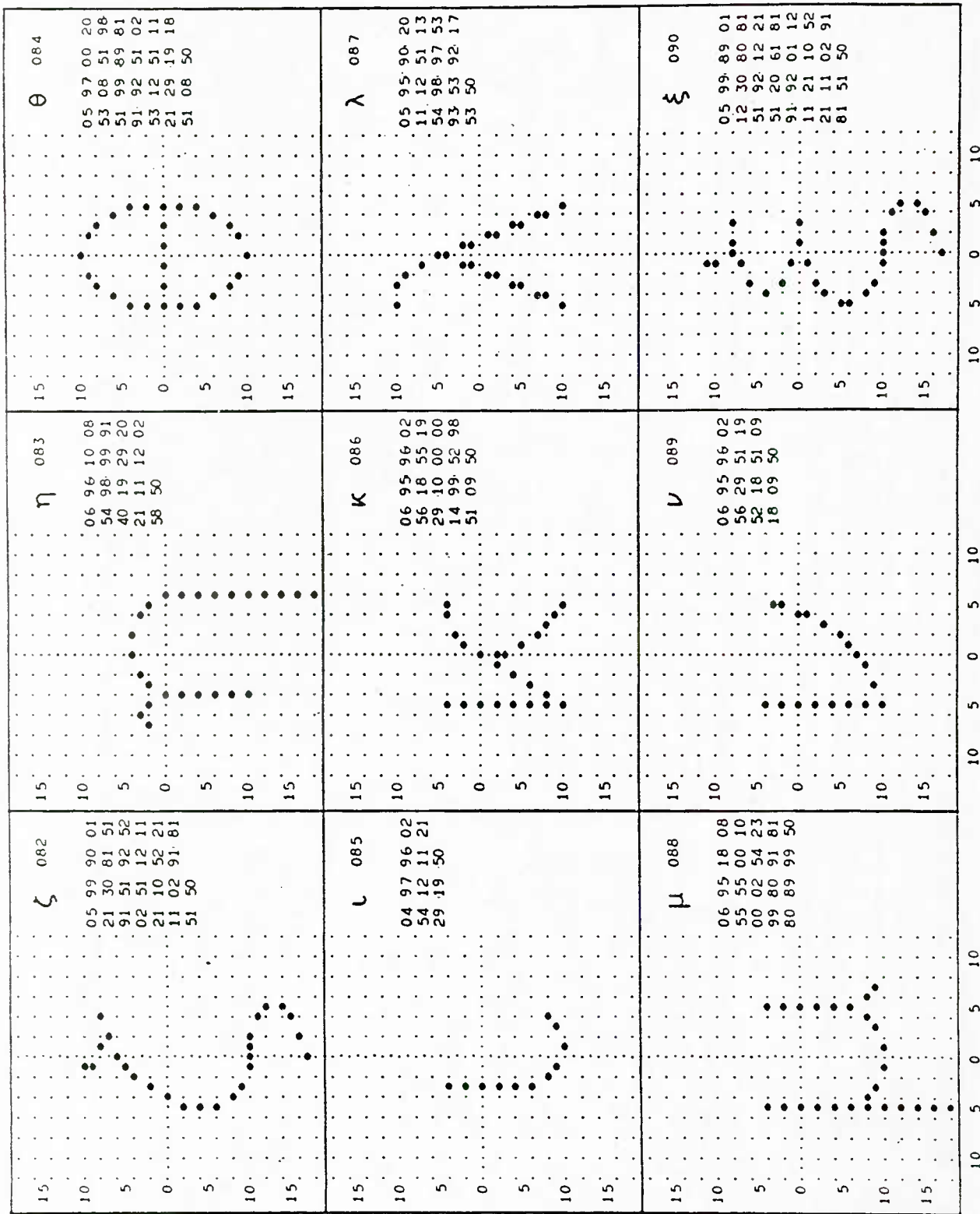


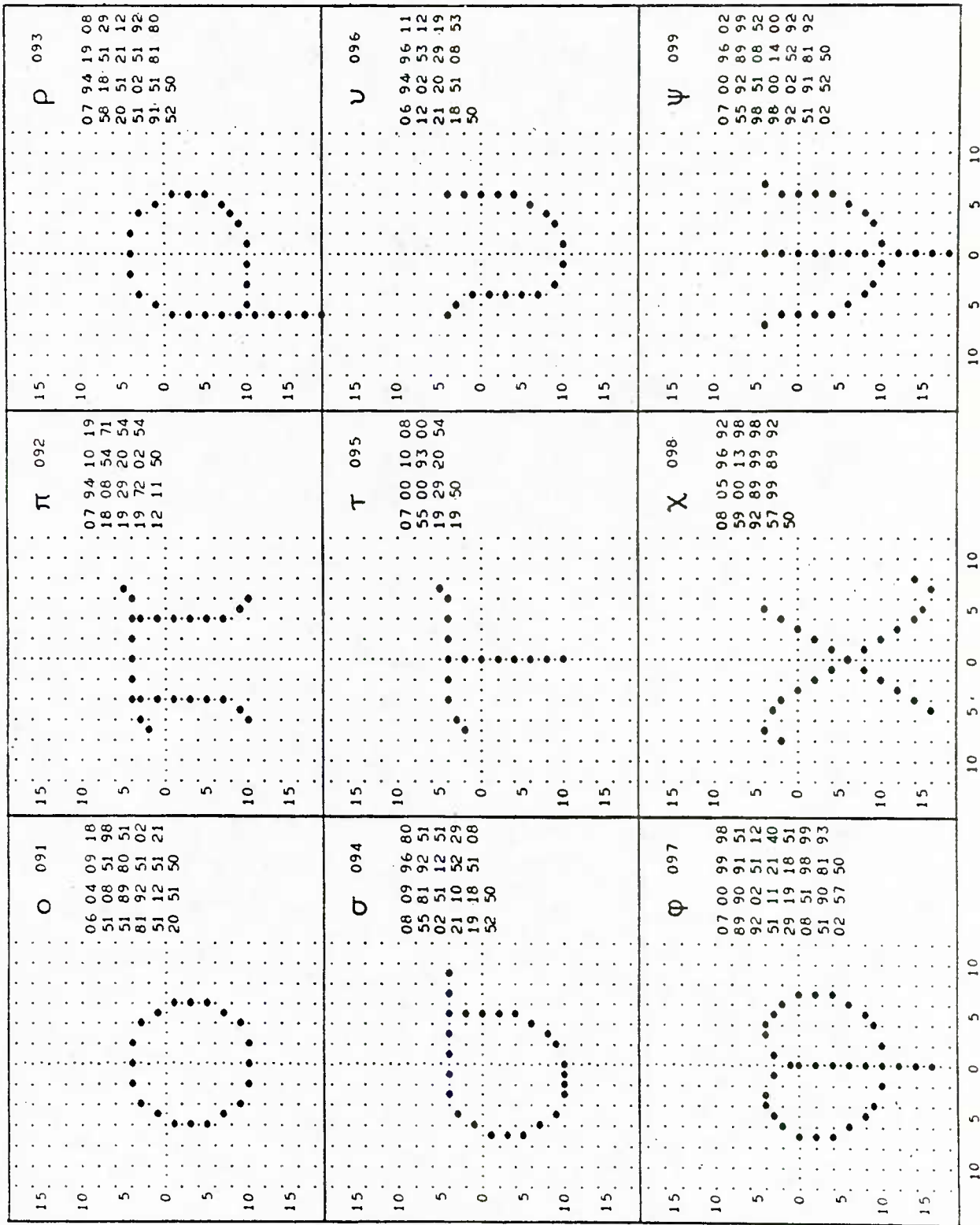
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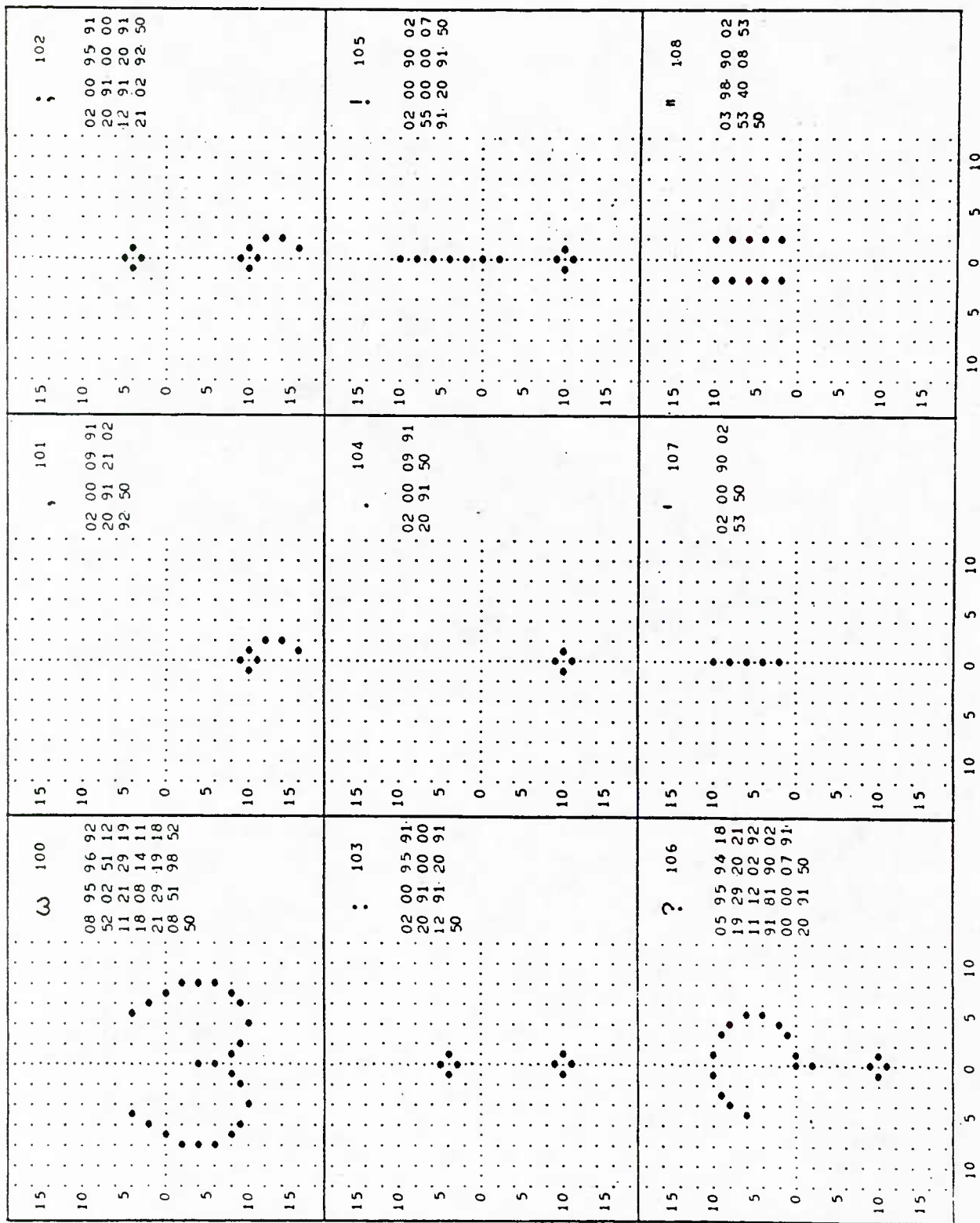


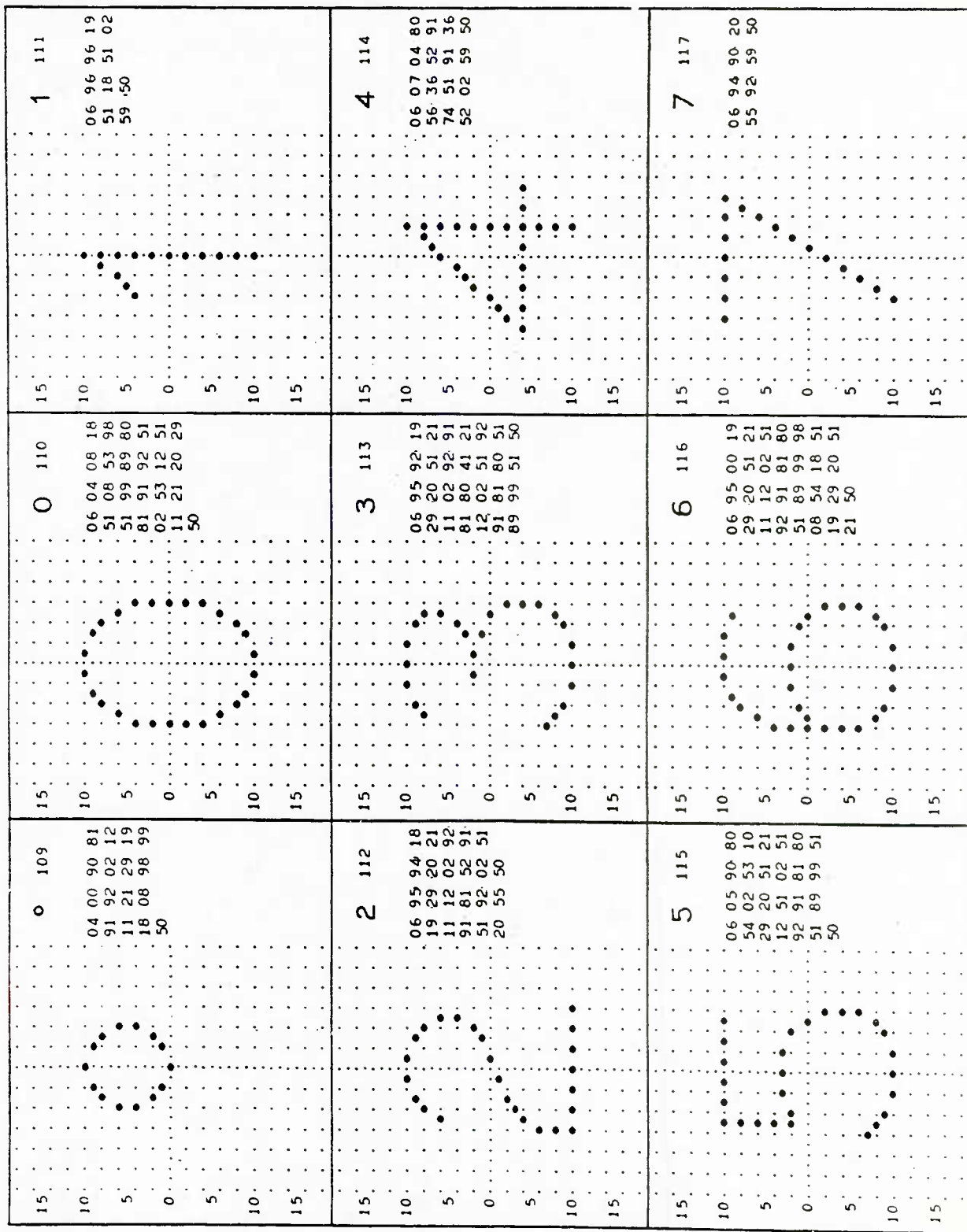
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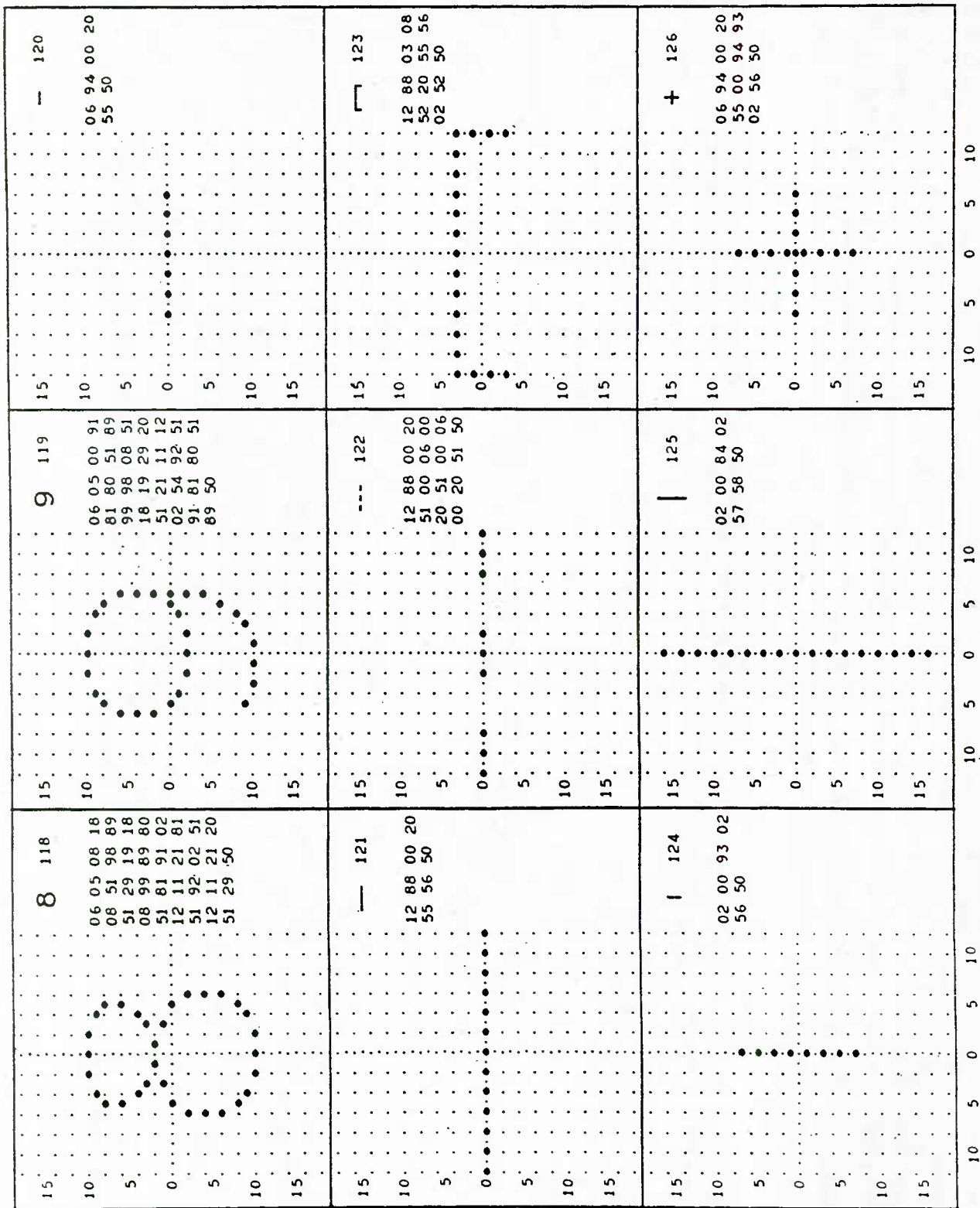


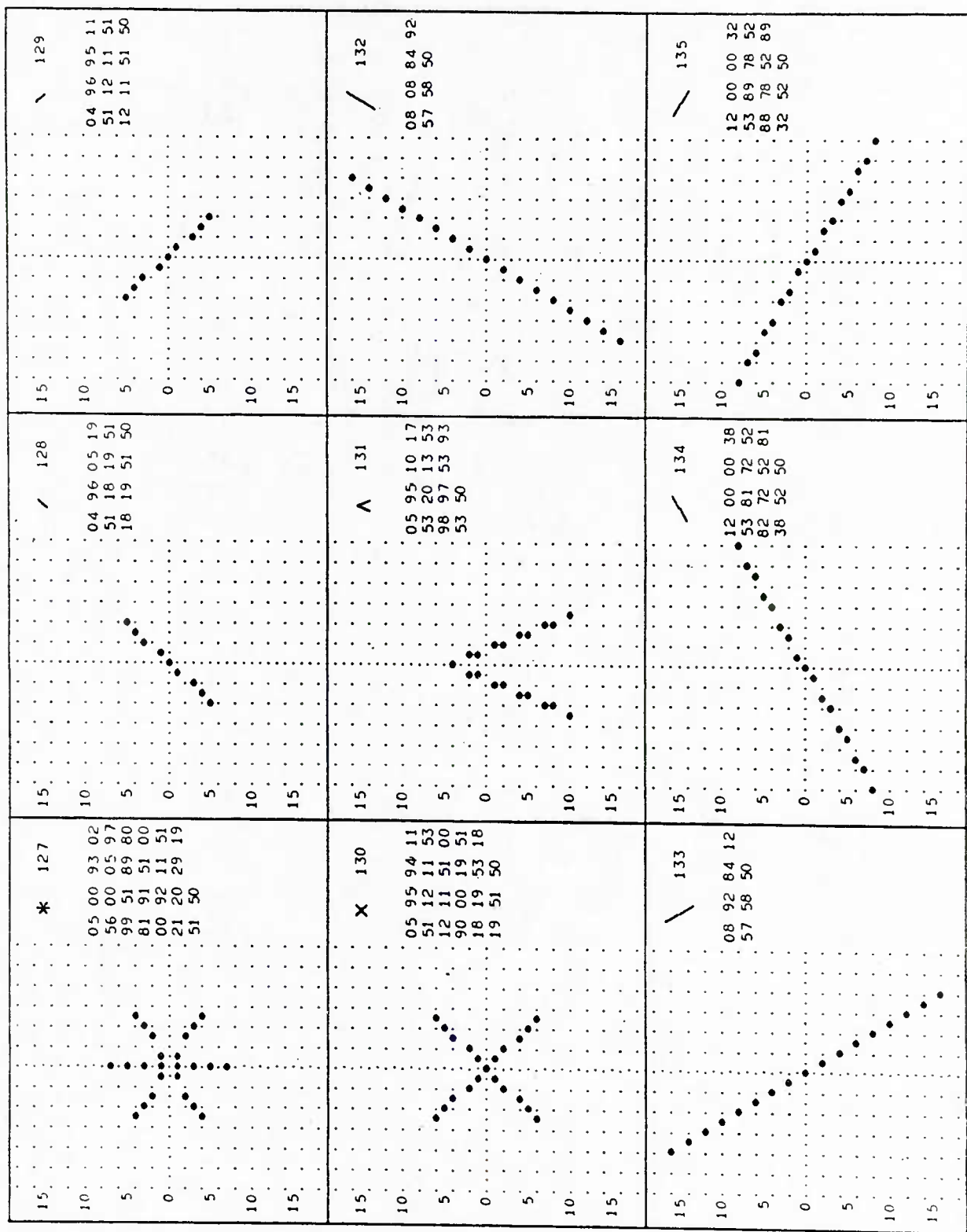


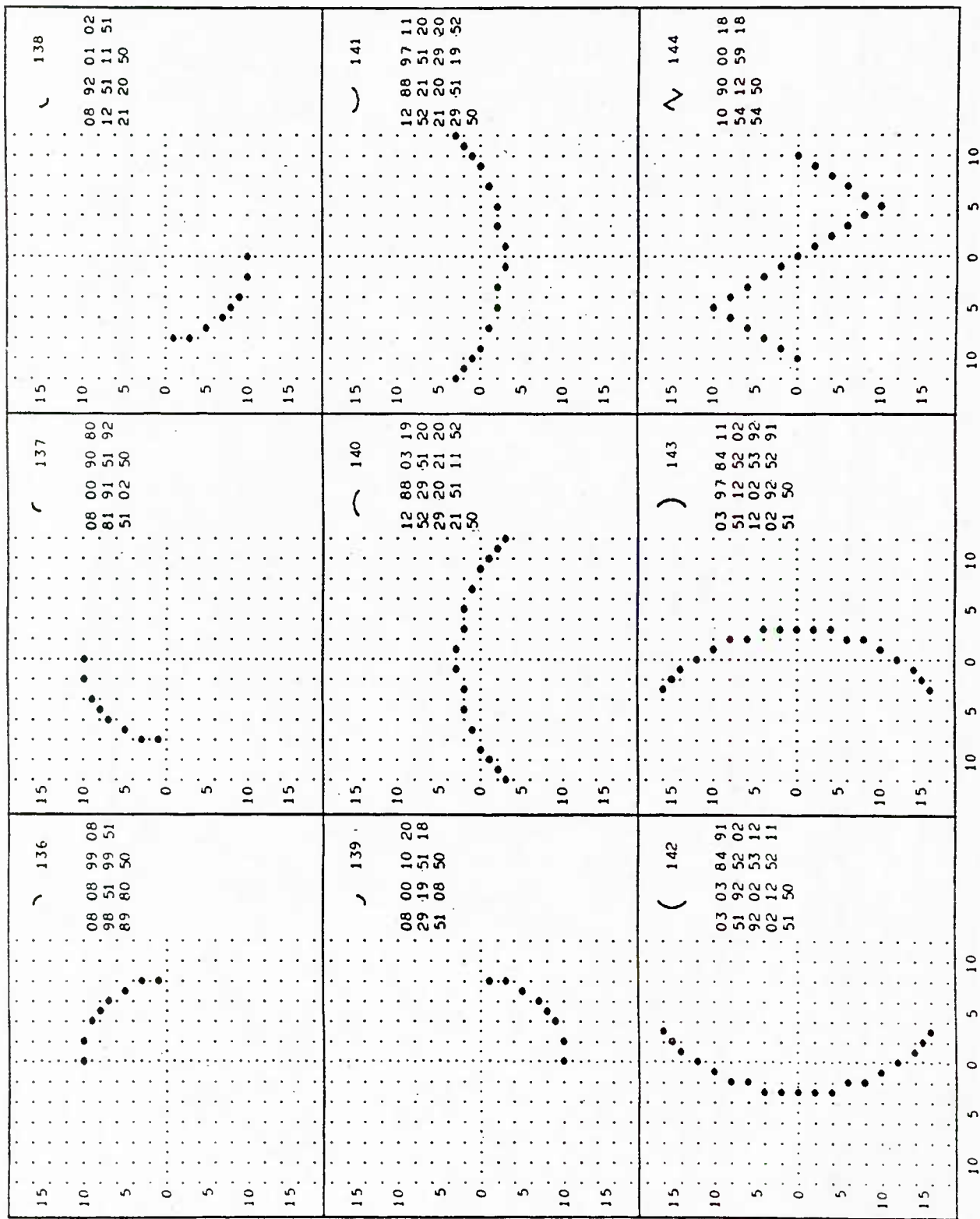


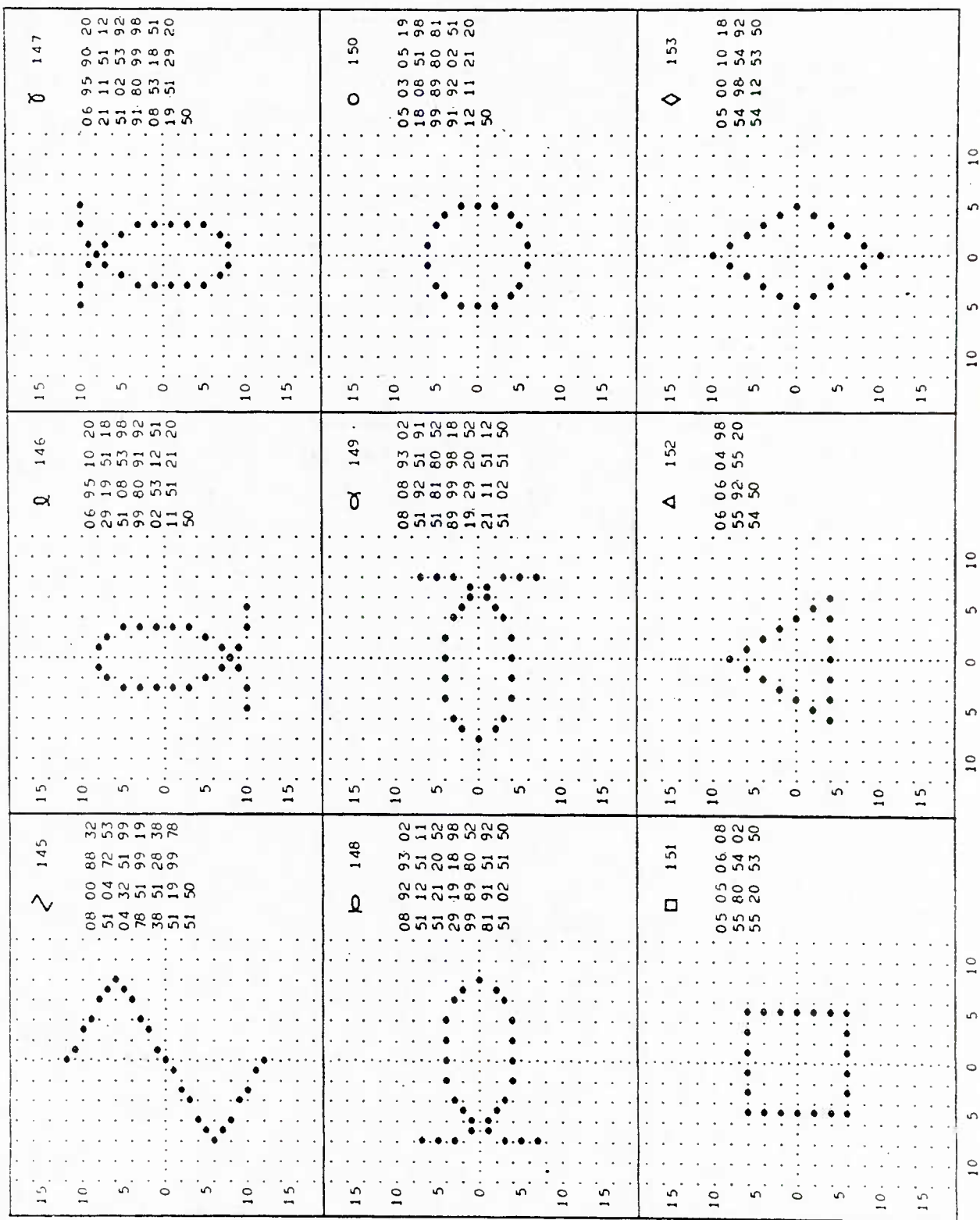


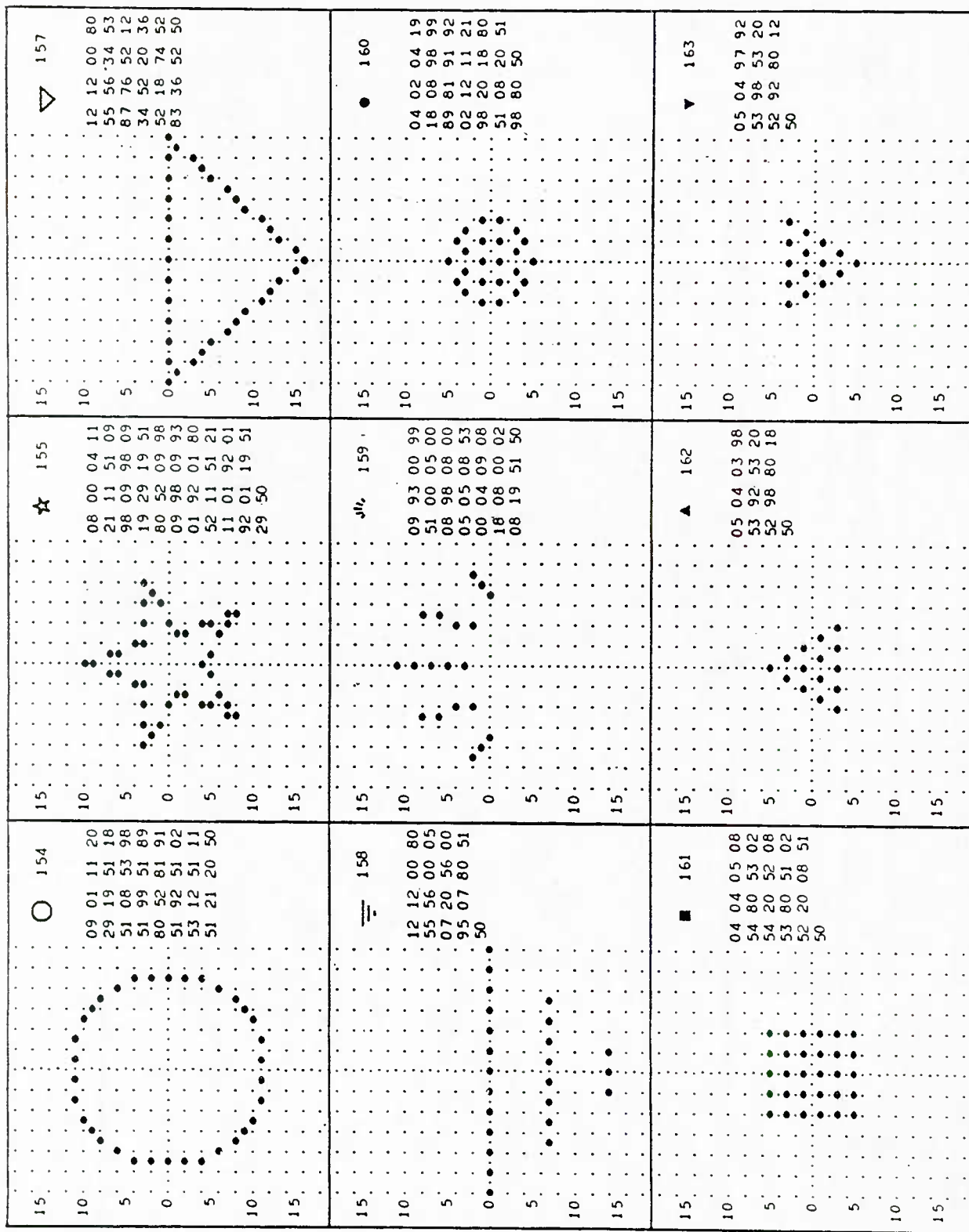




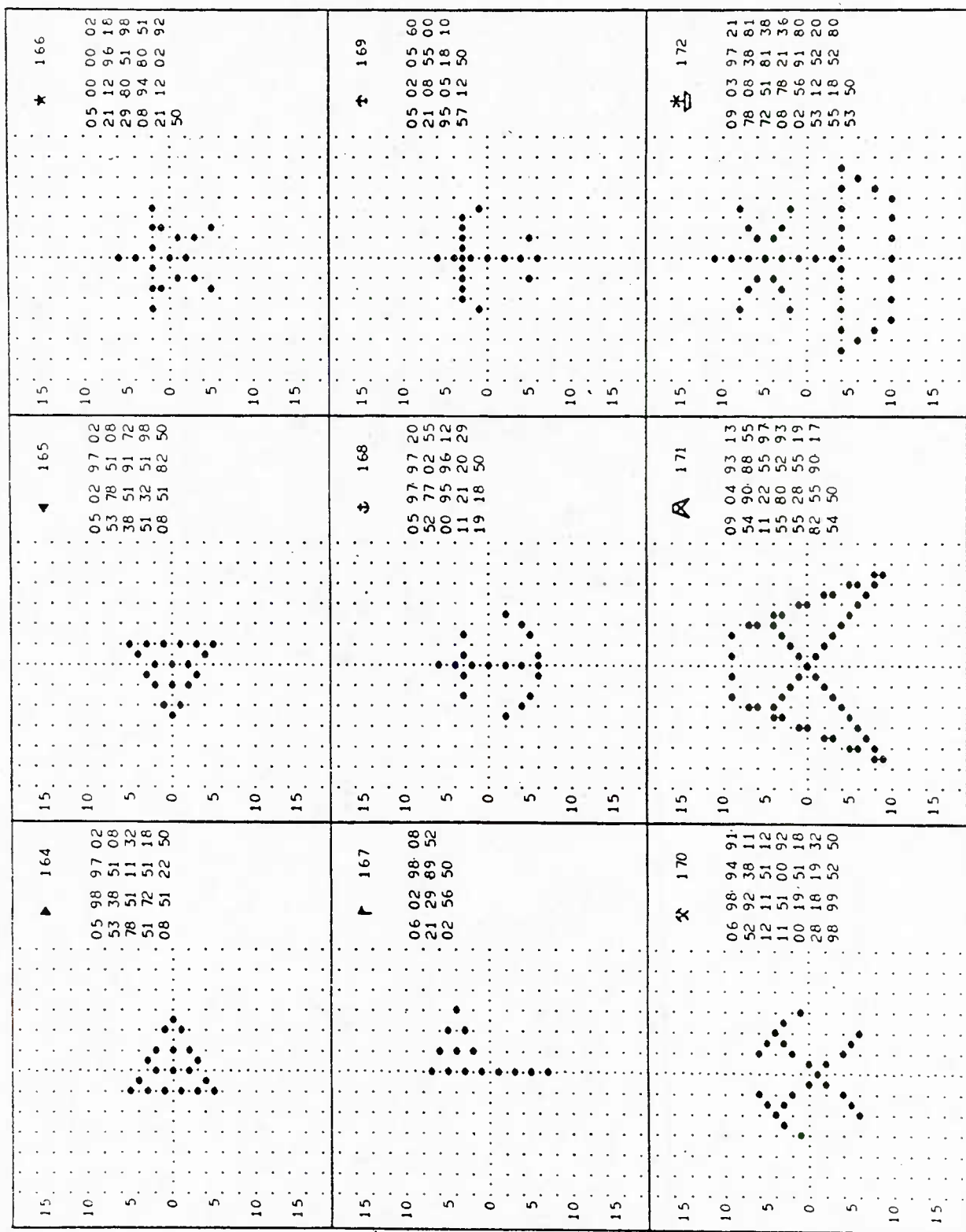






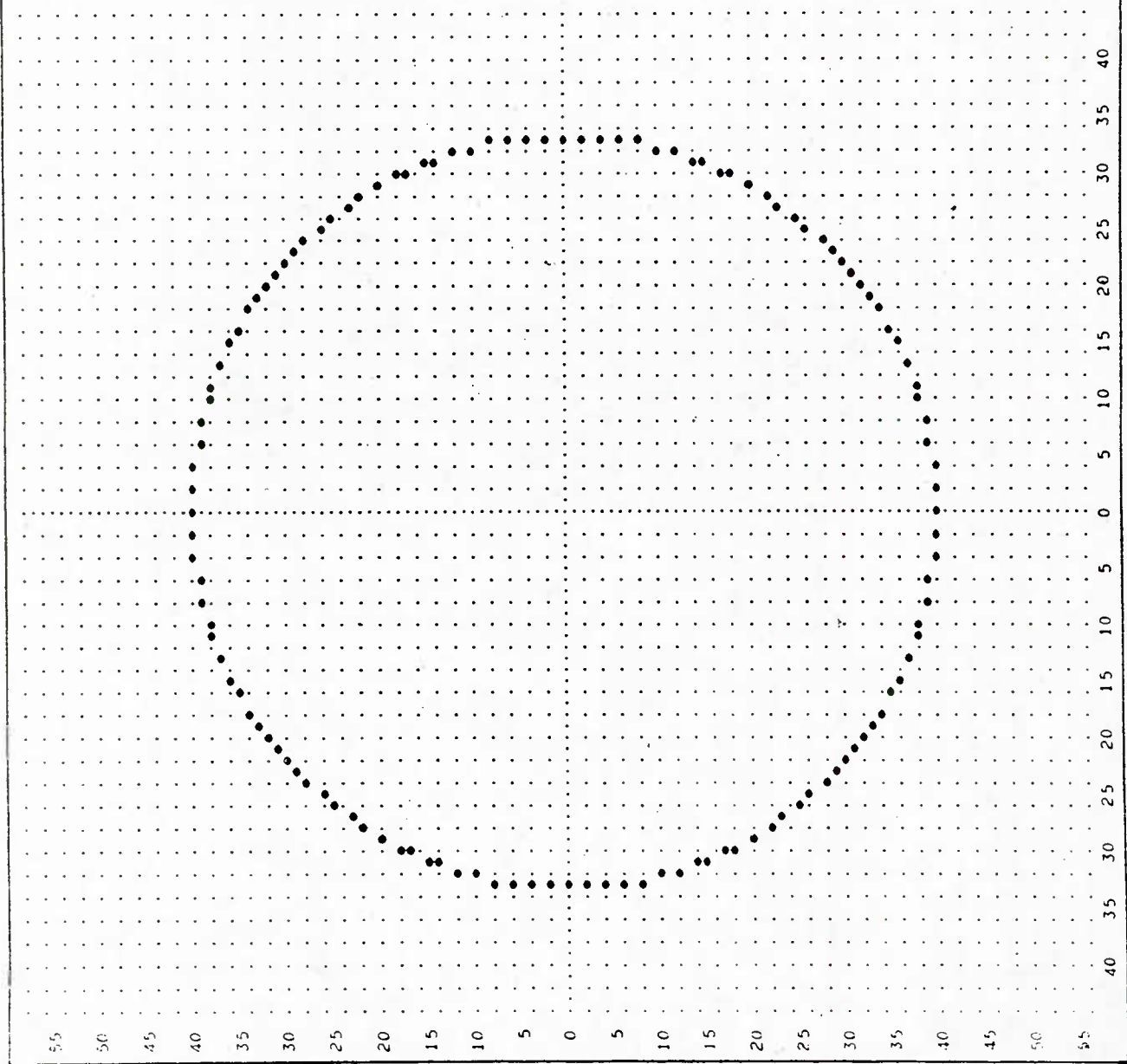


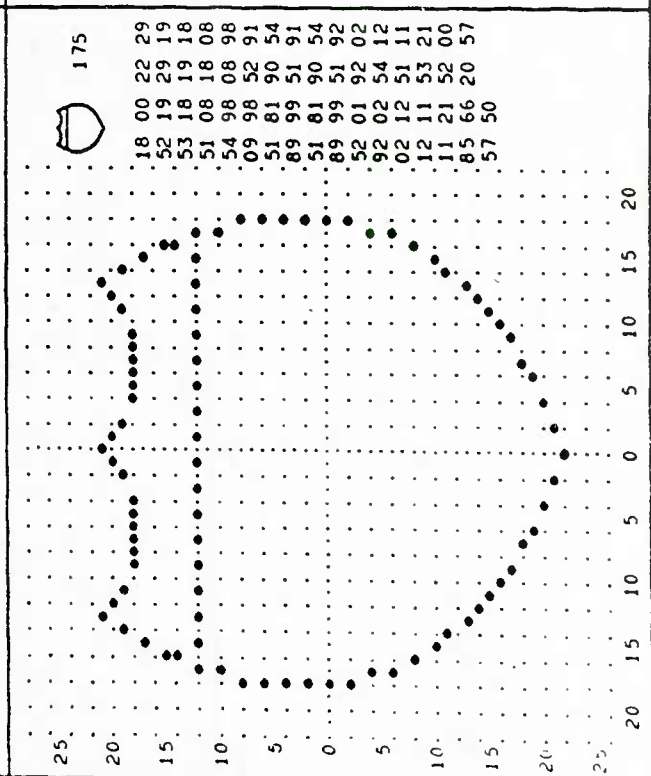
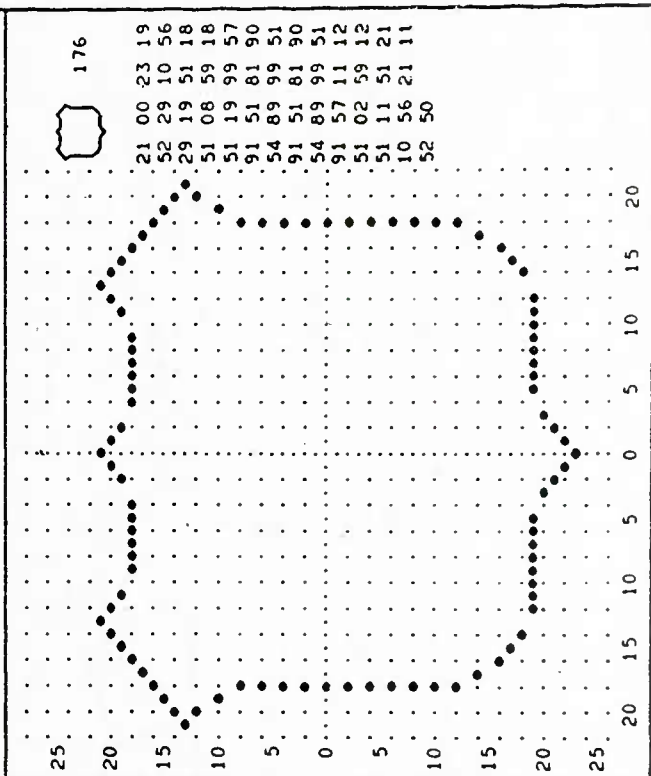
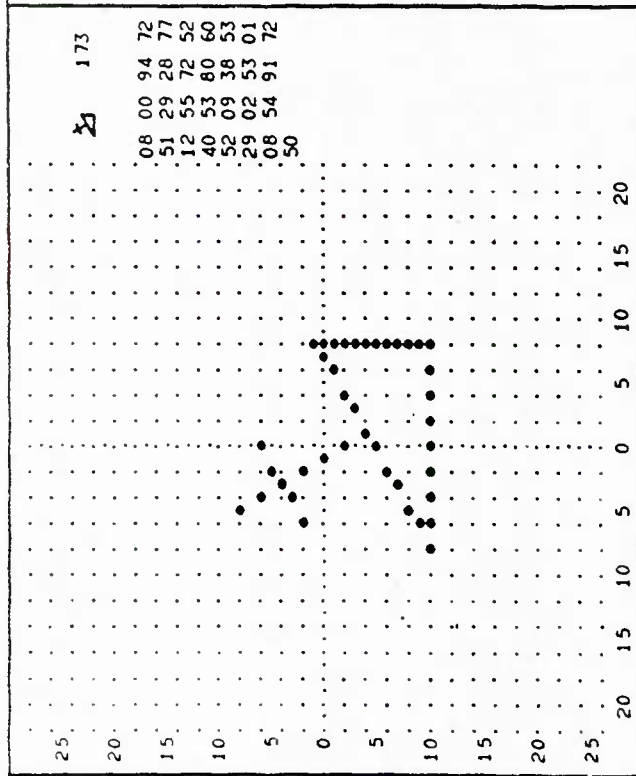
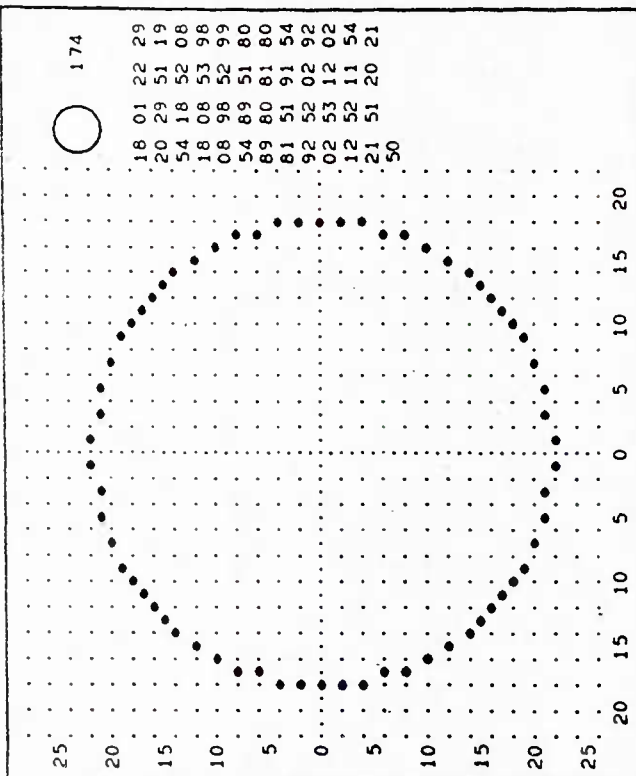
10 5 0 5 10 10 5 0 5 10 10 5 0 5 10

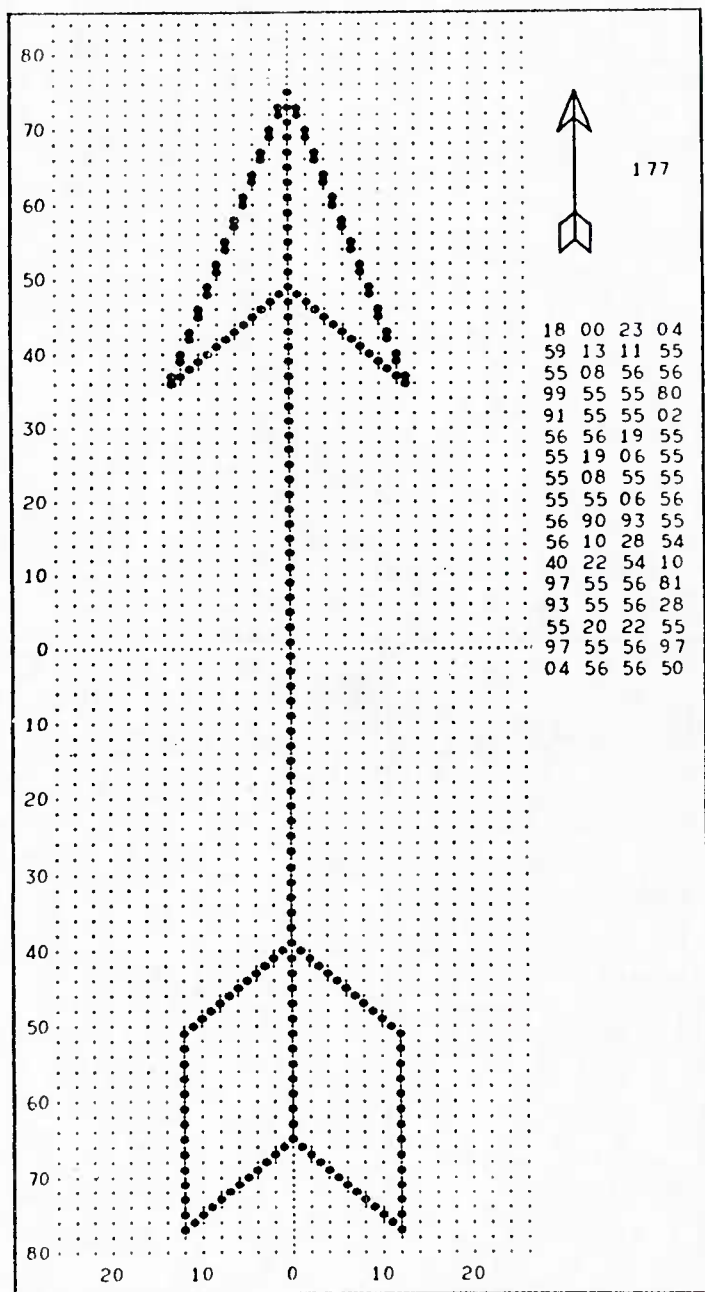




33 00 40 20 51 29 20 29
10 29 51 19 29 19 55 18
19 18 19 18 51 09 18 09
18 08 18 08 57 98 08 98
09 98 09 98 51 99 98 99
98 99 55 89 99 89 51 90
89 80 89 80 53 81 80 81
90 81 51 91 81 91 55 92
91 92 91 92 51 01 92 01
92 02 92 02 57 12 02 12
01 12 01 12 51 11 12 11
12 11 55 21 11 21 51 10
21 20 21 20 50

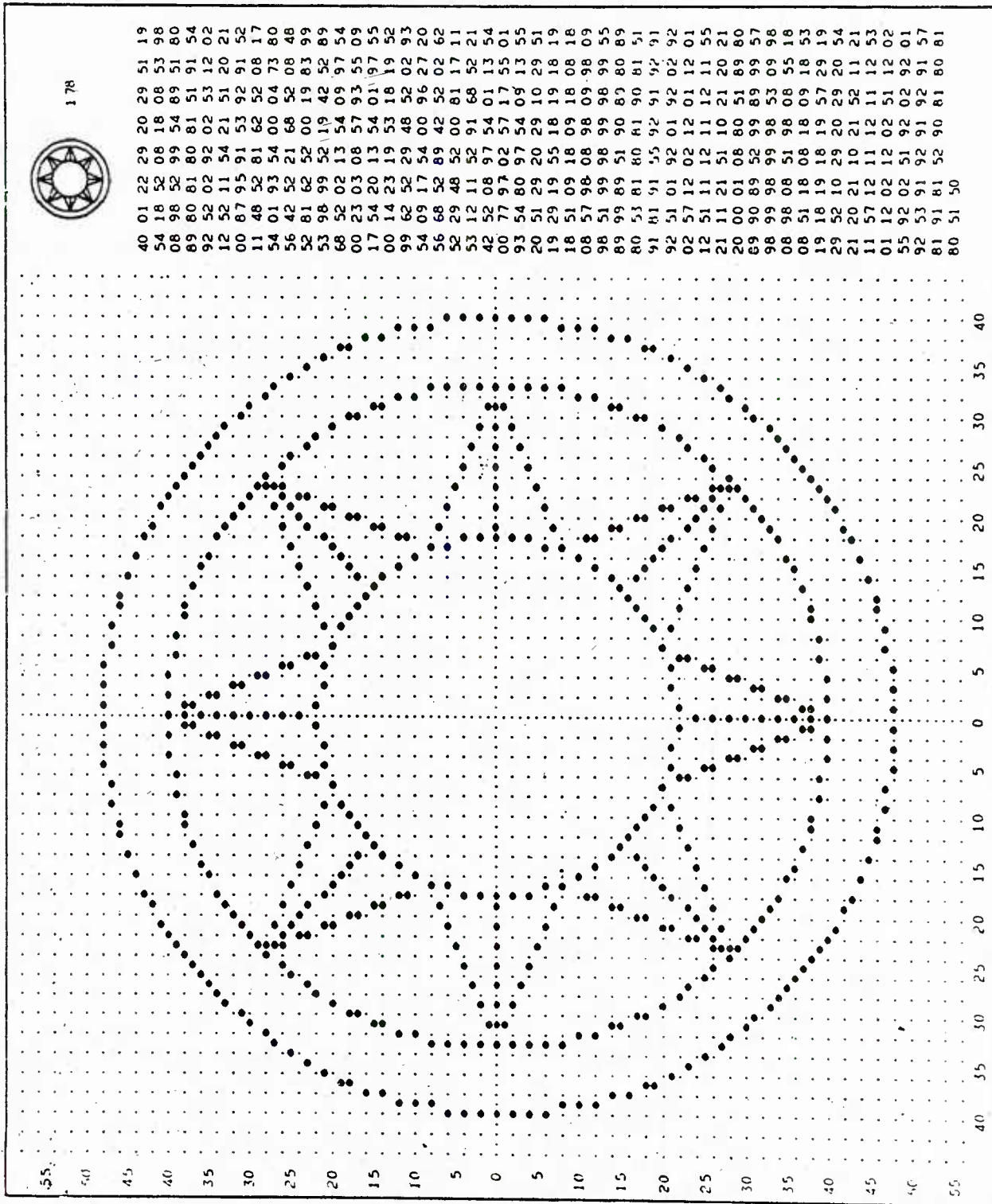








178



APPENDIX B

DIGITALIZATION WITH VECTORS

DECK 2524

The border of each panel indicates the scale in raster units with every 10th raster unit accentuated. The number in each panel is the number of the character. The dots on each side of the character indicate the width of the character block.

STRETCH SUBROUTINE TO READ CHARACTER DIGITALIZATION

SUBROUTINE RDCHDT (NU, AI, AD)

NU = SYMBOLIC UNIT NUMBER (FORTRAN INTEGER)

AI = INDEX ARRAY (SYMBOLIC ADDRESS)

AD = DATUM ARRAY (SYMBOLIC ADDRESS)

STRETCH SUBROUTINE TO EXTRACT CHARACTER DIGITALIZATION

SUBROUTINE XTCHDT (NC, AI, AD, AC)

NC = CHARACTER NUMBER (FORTRAN INTEGER)

AI = INDEX ARRAY (SYMBOLIC ADDRESS)

AD = DATUM ARRAY (SYMBOLIC ADDRESS)

AC = CHARACTER ARRAY (SYMBOLIC ADDRESS)

PART I

SIMPLEX REPERTORY

A. FORTRAN

B. Cartographic

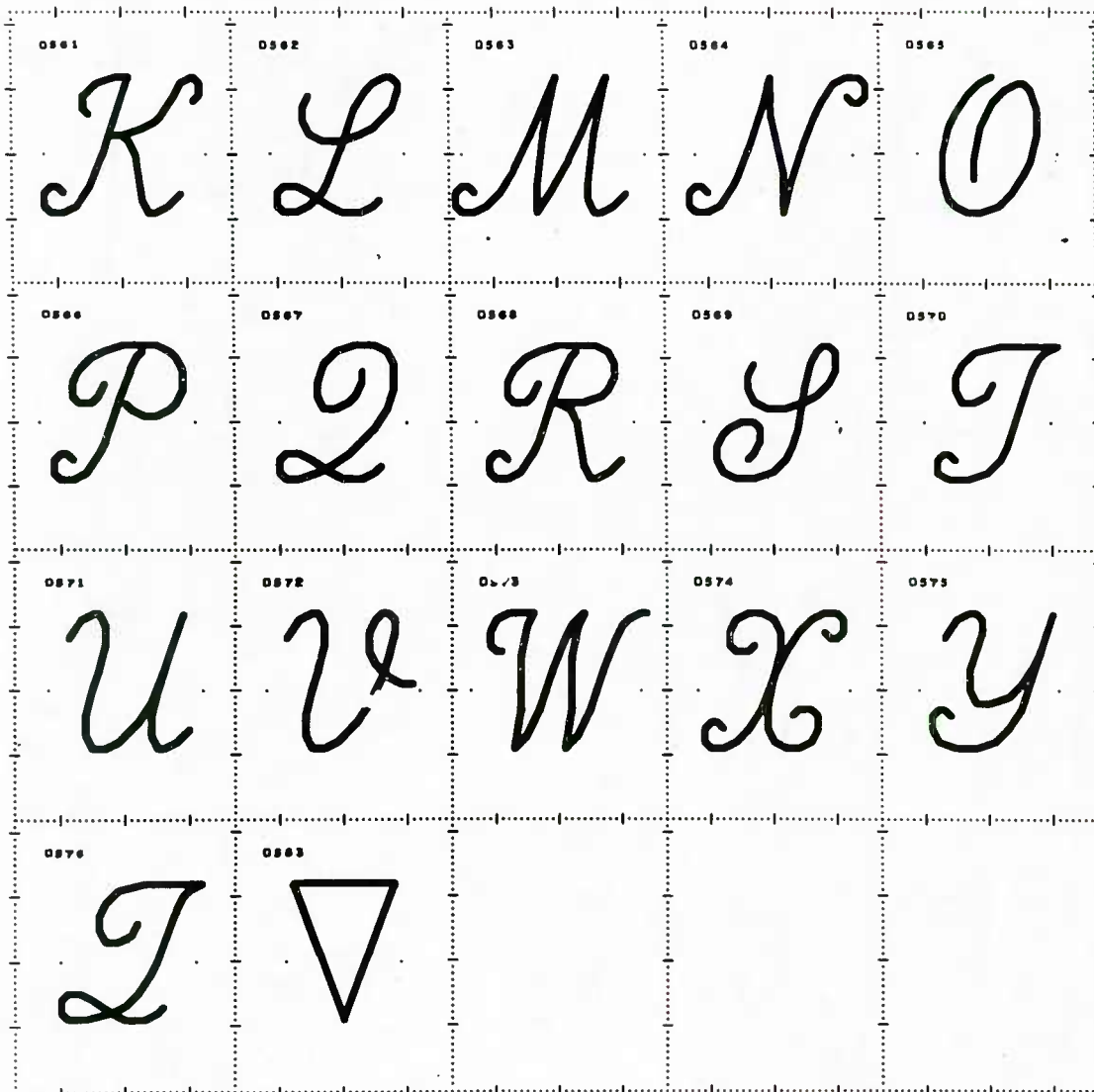
0001 A	0002 B	0003 C	0004 D	0005 E	0006 F	0007 G
0008 H	0009 I	0010 J	0011 K	0012 L	0013 M	0014 N
0015 O	0016 P	0017 Q	0018 R	0019 S	0020 T	0021 U
0022 V	0023 W	0024 X	0025 Y	0026 Z	0027 A	0028 B
0029 Г	0030 Δ	0031 E	0032 Z	0033 H	0034 Θ	0035 I
0036 K	0037 Λ	0038 M	0039 N	0040 Ξ	0041 O	0042 Π

0043 P	0044 Σ	0045 T	0046 Υ	0047 Φ	0048 X	0049 Ψ
0050 Ω	0198 .	0199 .	0200 0	0201 1	0202 2	0203 3
0204 4	0205 5	0206 6	0207 7	0208 8	0209 9	0210 .
0211 ,	0212 :	0213 ;	0214 !	0215 ?	0216 !	0217
0218 o	0219 \$	0220 /	0221 (0222)	0223 	0224 —
0225 +	0226 =	0227 ×	0228 *	0229 ◊		

0501 A	0502 B	0503 C	0504 D	0505 E
0506 F	0507 G	0508 H	0509 I	0510 J
0511 K	0512 L	0513 M	0514 N	0515 O
0516 P	0517 Q	0518 R	0519 S	0520 T



0541	0542	0543	0544	0545
O	Π	P	Σ	T
0546	0547	0548	0549	0550
Υ	Φ	X	Ψ	Ω
0551	0552	0553	0554	0555
A	B	C	D	E
0556	0557	0558	0559	0560
F	G	H	I	J



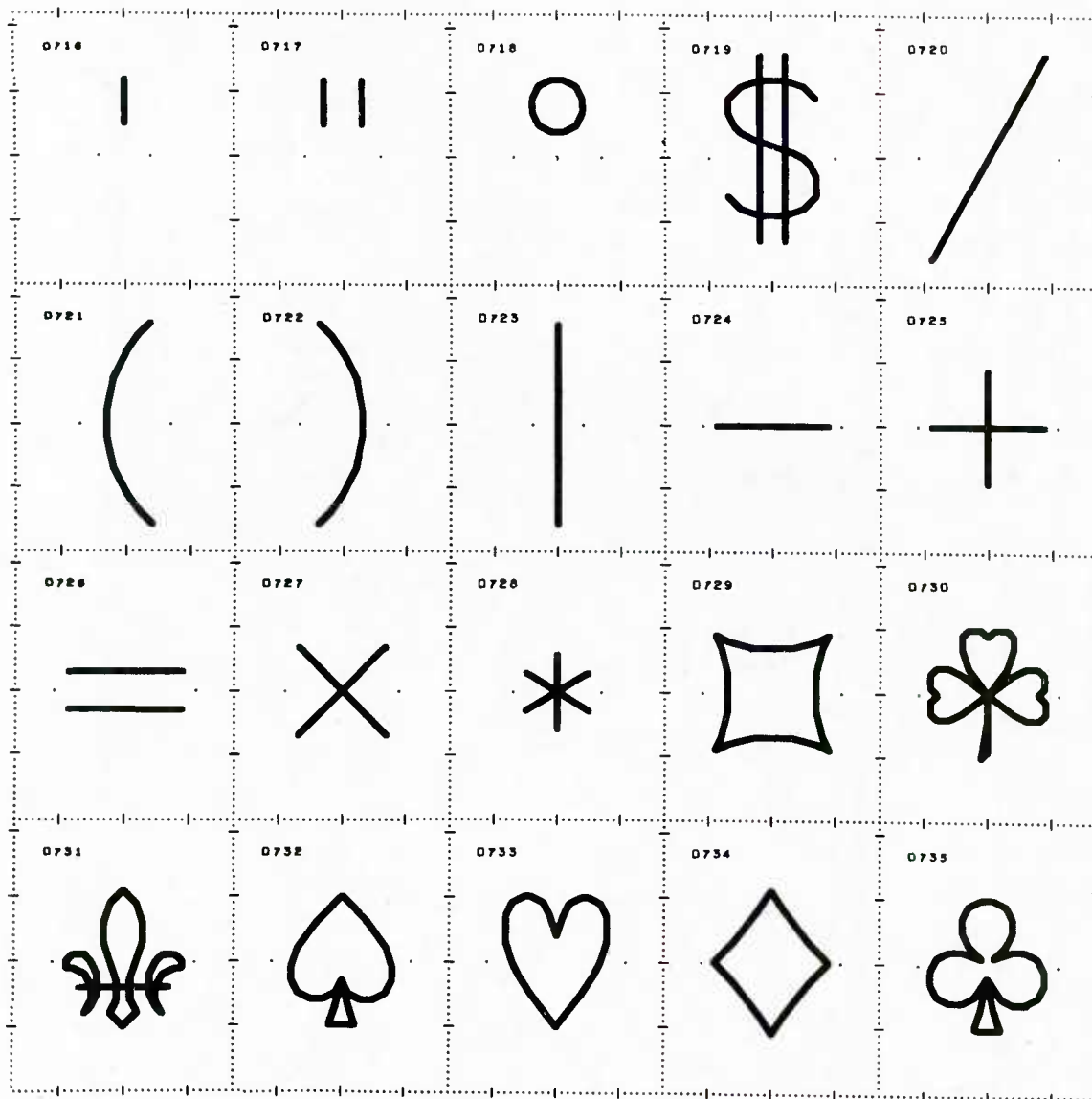
0601 a	0602 b	0603 c	0604 d	0605 e
0606 f	0607 g	0608 h	0609 i	0610 j
0611 k	0612 l	0613 m	0614 n	0615 o
0616 p	0617 q	0618 r	0619 s	0620 t

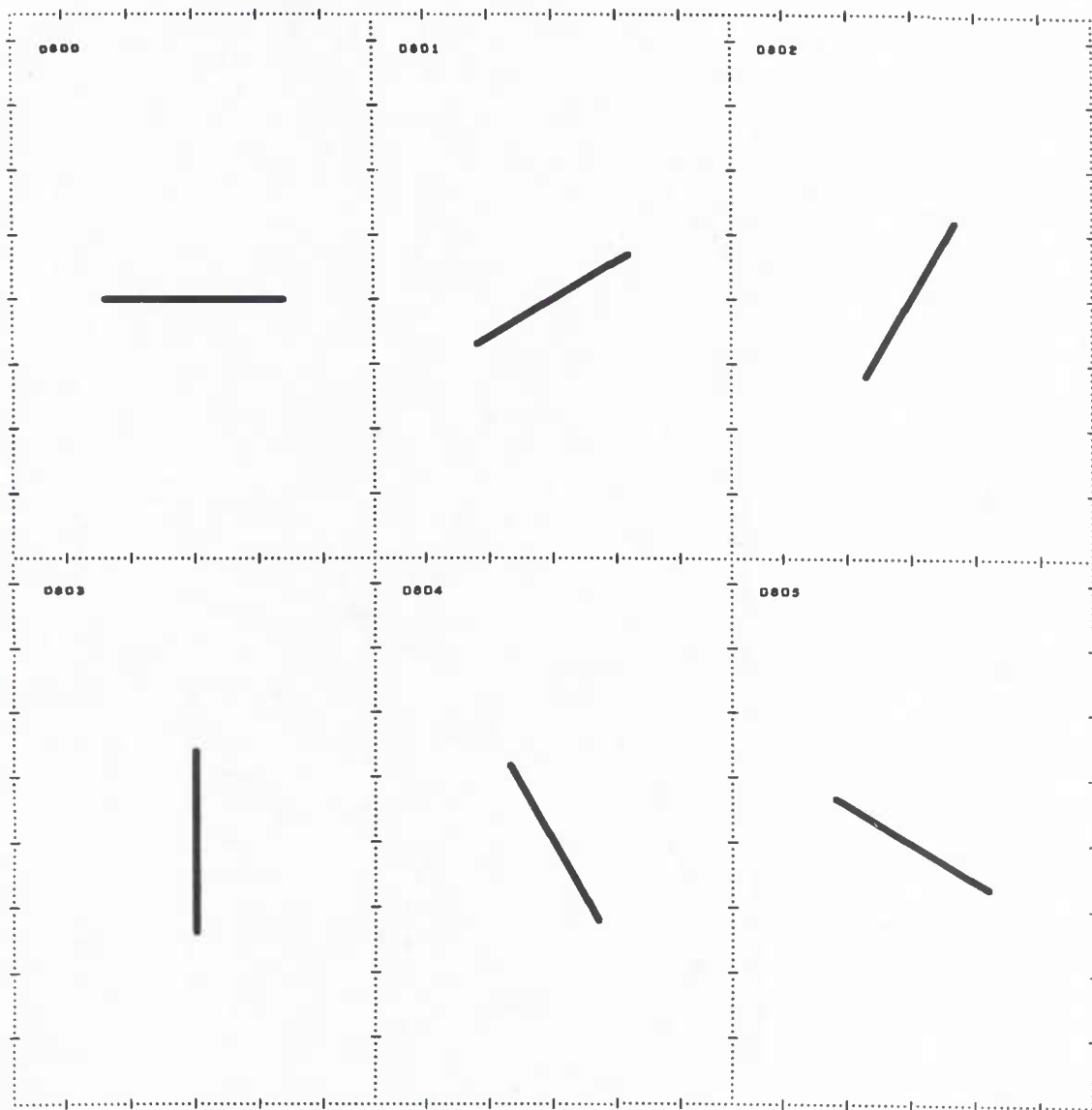
0621	0622	0623	0624	0625
u	v	w	x	y
0626	0627	0628	0629	0630
z	a	β	γ	δ
0631	0632	0633	0634	0635
ε	ζ	η	ϑ	ι
0636	0637	0638	0639	0640
κ	λ	μ	ν	ξ













0641 O	0642 π	0643 ρ	0644 σ	0645 τ
0646 υ	0647 φ	0648 χ	0649 ψ	0650 ω
0651 α	0652 β	0653 γ	0654 δ	0655 ε
0656 f	0657 g	0658 h	0659 i	0660 j







D661	D662	D663	D664	D665
k	l	m	n	o
D666	D667	D668	D669	D670
p	q	r	s	t
D671	D672	D673	D674	D675
u	v	w	x	y
D676	D683	D684	D685	D686
z	ð	€	θ	φ

	0698	0699	0700	0701
	.	.	0	1
0702	0703	0704	0705	0706
2	3	4	5	6
0707	0708	0709	0710	0711
7	8	9	.	,
0712	0713	0714	0715	
:	;	!	?	





0806	0807	0808	0809
			
0810	0811	0812	0813
			
0814	0815	0816	0817
			

<p>0620</p> 	<p>0622</p> 	<p>0624</p> 
<p>0621</p> 	<p>0623</p> 	<p>0625</p> 

0830



0831



0832

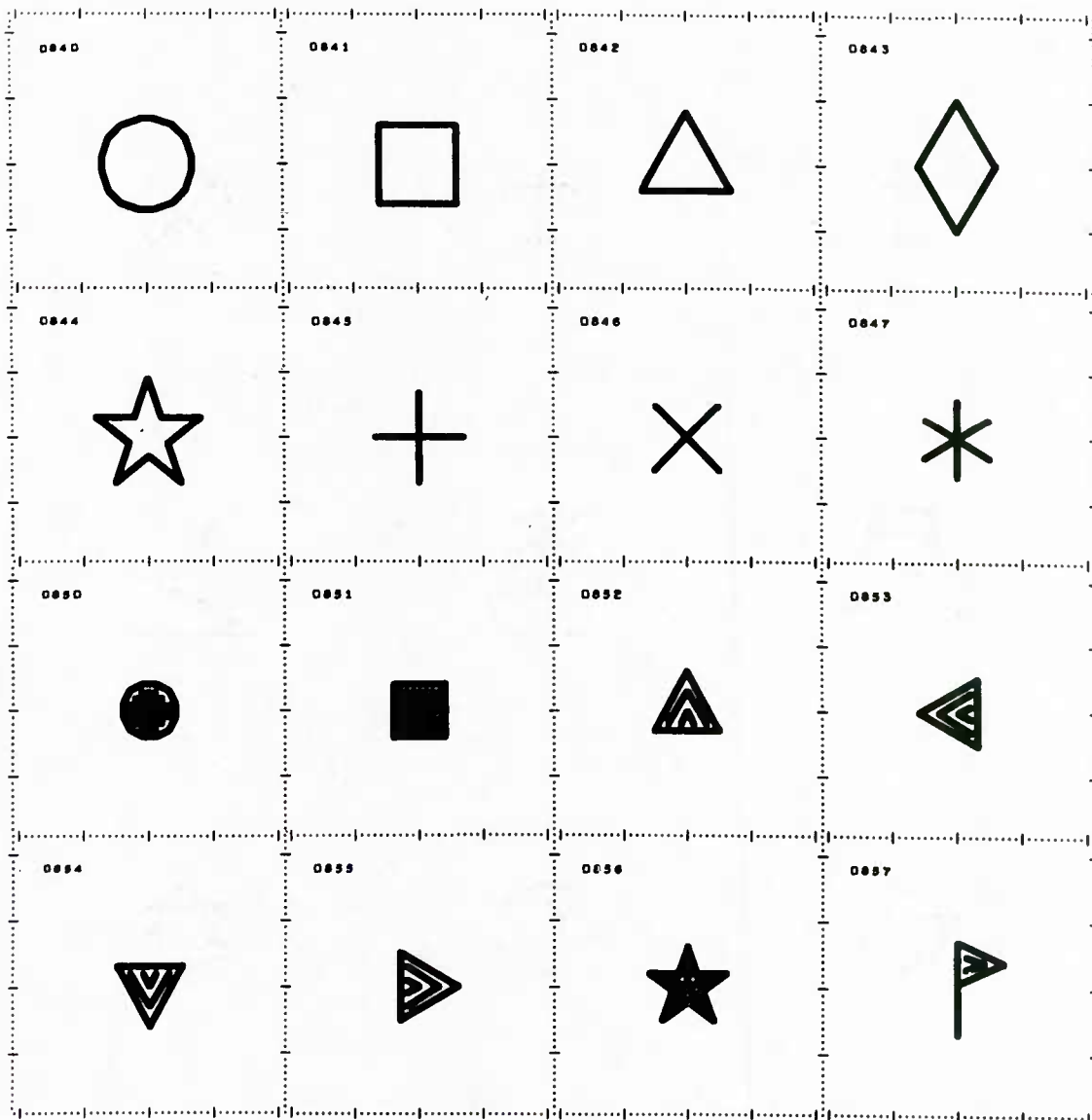


0833



0834





0860



0861



0862



0863



0864



0865



0866

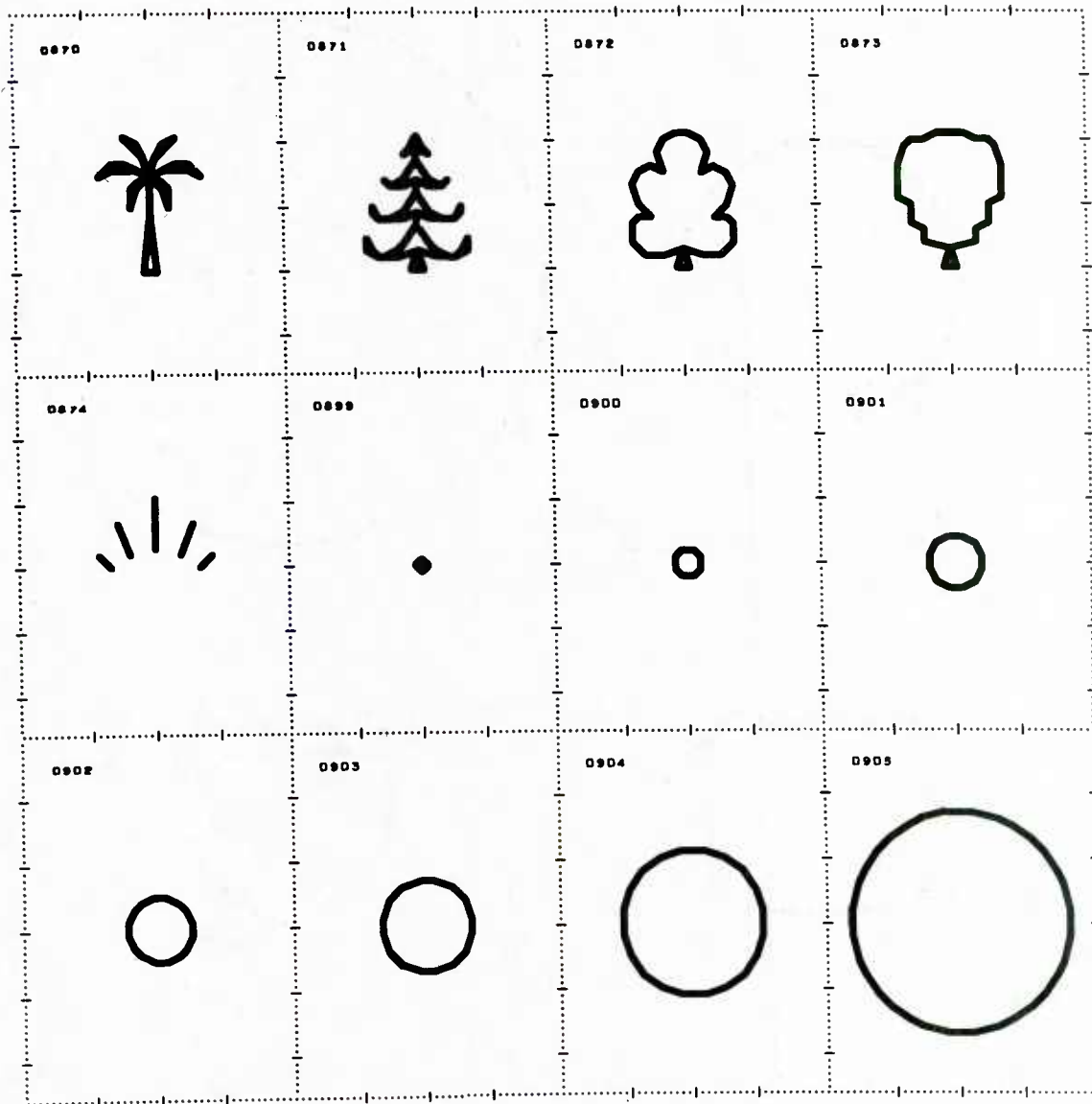


0867

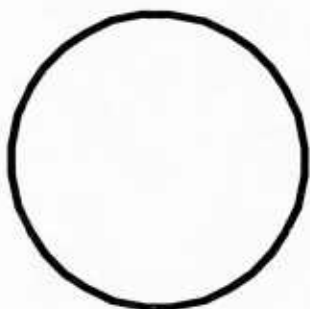


0868

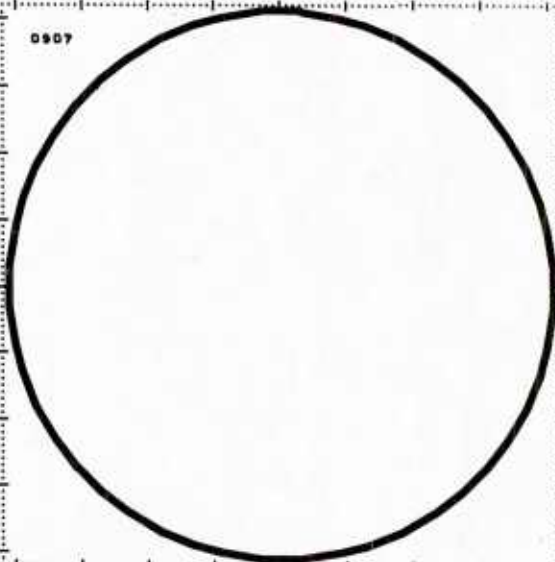




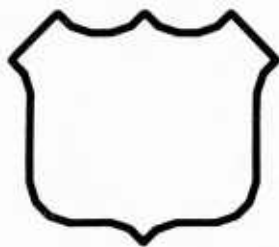
0906



0907



0908



0909



PART II

DUPLEX REPERTORY

A. Indexical

B. Principal

1001	1002	1003	1004	1005
A	B	C	D	E
1006	1007	1008	1009	1010
F	G	H	I	J
1011	1012	1013	1014	1015
K	L	M	N	O
1016	1017	1018	1019	1020
P	Q	R	S	T

1021	1022	1023	1024	1025
U	V	W	X	Y
1026	1027	1028	1029	1030
Z	A	B	Г	Δ
1031	1032	1033	1034	1035
E	Z	H	⊙	I
1036	1037	1038	1039	1040
K	Λ	M	N	Ξ

1041	1042	1043	1044	1045
Ο	Π	Ρ	Σ	Τ
1046	1047	1048	1049	1050
Υ	Φ	Χ	Ψ	Ω
1051	1052	1053	1054	1055
<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>
1056	1057	1058	1059	1060
<i>F</i>	<i>G</i>	<i>H</i>	<i>I</i>	<i>J</i>

1061 <i>K</i>	1062 <i>L</i>	1063 <i>M</i>	1064 <i>N</i>	1065 <i>O</i>
1066 <i>P</i>	1067 <i>Q</i>	1068 <i>R</i>	1069 <i>S</i>	1070 <i>T</i>
1071 <i>U</i>	1072 <i>V</i>	1073 <i>W</i>	1074 <i>X</i>	1075 <i>Y</i>
1076 <i>Z</i>				

1101 a	1102 b	1103 c	1104 d	1105 e
1106 f	1107 g	1108 h	1109 i	1110 j
1111 k	1112 l	1113 m	1114 n	1115 o
1116 p	1117 q	1118 r	1119 s	1120 t

1121	1122	1123	1124	1125
u	v	w	x	y
1126	1127	1128	1129	1130
z	α	β	γ	δ
1131	1132	1133	1134	1135
ε	ζ	η	θ	ι
1136	1137	1138	1139	1140
κ	λ	μ	ν	ξ

1141 o	1142 π	1143 ρ	1144 σ	1145 τ
1146 υ	1147 φ	1148 χ	1149 ψ	1150 ω
1151 a	1152 b	1153 c	1154 d	1155 e
1156 f	1157 g	1158 h	1159 i	1160 j

1161 <i>k</i>	1162 <i>l</i>	1163 <i>m</i>	1164 <i>n</i>	1165 <i>o</i>
1166 <i>p</i>	1167 <i>q</i>	1168 <i>r</i>	1169 <i>s</i>	1170 <i>t</i>
1171 <i>u</i>	1172 <i>v</i>	1173 <i>w</i>	1174 <i>x</i>	1175 <i>y</i>
1176 <i>z</i>				

1177	1178	1179	1180	1181
ff	fi	fl	ffi	ffl
1184	1185	1186		
€	θ	ϕ		
1191	1192	1193	1194	1195
<i>ff</i>	<i>fi</i>	<i>fl</i>	<i>ffi</i>	<i>ffl</i>
			1198	1199

1200	1201	1202	1203	1204
0	1	2	3	4
1205	1206	1207	1208	1209
5	6	7	8	9
1210	1211	1212	1213	1214
.	,	:	;	!
1215	1216	1217	1218	1219
?	!	"	o	*

1220 /	1221 ()	1222)	1223 [1224]
1225 { }	1226 }	1227 <	1228 >	1229
1230 	1231 —	1232 +	1233 ±	1234 ≠
1235 ×	1236 •	1237 ÷		

1238	1239	1240	1241	1242
$=$	\neq	\equiv	$<$	$>$
1243	1244	1245	1246	1247
\leq	\geq	∞	\approx	\wedge
1261	1262	1263	1264	1265
\rightarrow	\uparrow	\leftarrow	\downarrow	∂
1266	1267	1268	1269	1270
∇	\checkmark	\int	\oint	∞

1271	1272	1273	1274	1275
%	&	@	\$	#
1276	1277	1278		
§	†	‡		
1281	1282	1283	1284	1285
⊙	♀	♀	⊕	♂
1286	1287	1288	1289	1290
℥	℥	♂	♂	ℙ

1291



1292



1293



1294



1295



2001 A	2002 B	2003 C	2004 D	2005 E
2006 F	2007 G	2008 H	2009 I	2010 J
2011 K	2012 L	2013 M	2014 N	2015 O
2016 P	2017 Q	2018 R	2019 S	2020 T

2021	2022	2023	2024	2025
U	V	W	X	Y
2026	2027	2028	2029	2030
Z	A	B	Г	Δ
2031	2032	2033	2034	2035
E	Z	H	⊙	I
2036	2037	2038	2039	2040
K	Λ	M	N	Ξ

2041	2042	2043	2044	2045
Ο	Π	Ρ	Σ	Τ
2046	2047	2048	2049	2050
Υ	Φ	Χ	Ψ	Ω
2051	2052	2053	2054	2055
<i>Α</i>	<i>Β</i>	<i>Γ</i>	<i>Δ</i>	<i>Ε</i>
2056	2057	2058	2059	2060
<i>Ζ</i>	<i>Η</i>	<i>Θ</i>	<i>Ι</i>	<i>Κ</i>

2061 <i>K</i>	2062 <i>L</i>	2063 <i>M</i>	2064 <i>N</i>	2065 <i>O</i>
2066 <i>P</i>	2067 <i>Q</i>	2068 <i>R</i>	2069 <i>S</i>	2070 <i>T</i>
2071 <i>U</i>	2072 <i>V</i>	2073 <i>W</i>	2074 <i>X</i>	2075 <i>Y</i>
2076 <i>Z</i>	2077 <i>x</i>			

2101 a	2102 b	2103 c	2104 d	2105 e
2106 f	2107 g	2108 h	2109 i	2110 j
2111 k	2112 l	2113 m	2114 n	2115 o
2116 p	2117 q	2118 r	2119 s	2120 t

2121	2122	2123	2124	2125
u	v	w	x	y
2126	2127	2128	2129	2130
z	α	β	γ	δ
2131	2132	2133	2134	2135
ε	ζ	η	θ	ι
2136	2137	2138	2139	2140
κ	λ	μ	ν	ξ

2141 o	2142 π	2143 ρ	2144 σ	2145 τ
2146 υ	2147 φ	2148 χ	2149 ψ	2150 ω
2151 α	2152 β	2153 γ	2154 δ	2155 ε
2156 f	2157 g	2158 h	2159 i	2160 j

2161

k

2162

l

2163

m

2164

n

2165

o

2166

p

2167

q

2168

r

2169

s

2170

t

2171

u

2172

v

2173

w

2174

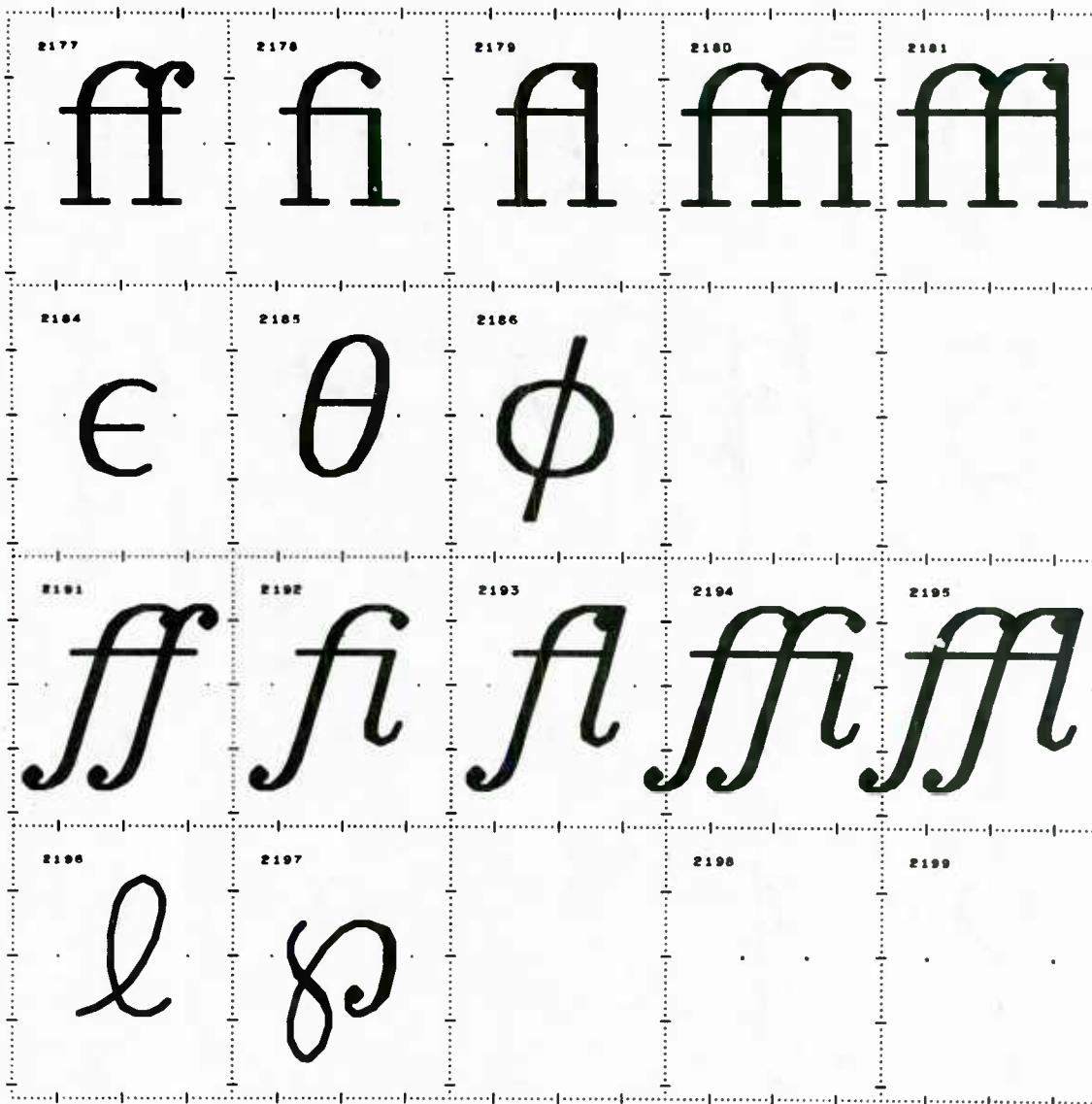
x

2175



















y

2176

z







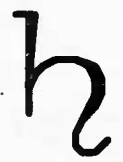















2200	2201	2202	2203	2204
0	1	2	3	4
2205	2206	2207	2208	2209
5	6	7	8	9
2210	2211	2212	2213	2214
.	,	:	;	!
2215	2216	2217	2218	2219
?	!	''	o	*

2220 	2221 	2222 	2223 	2224 
2225 	2226 	2227 	2228 	2229 
2230 	2231 	2232 	2233 	2234 
2235 	2236 	2237 		

2238	2239	2240	2241	2242
=	≠	≡	<	>
2243	2244	2245	2246	
≤	≥	∞	~	
2251	2252	2253	2254	2255
	⊥	∠	∴	√
2256	2257	2258	2259	2260
⊂	⊆	⊃	⊈	∈

2261	2262	2263	2264	2265
→	↑	←	↓	∂
2266	2267	2268	2269	2270
▽	✓	∫	ℳ	∞
2271	2272	2273	2274	2275
%	&	@	\$	#
2276	2277	2278		
§	†	‡		

2281	2282	2283	2284	2285
				
2286	2287	2288	2289	2290
				
2301	2302	2303	2304	2305
				
2306	2307	2308	2309	2310
				

2311



2312



2318



2319



2320



2321



2322



2323



2324



2325



2326



2327



2328



2329



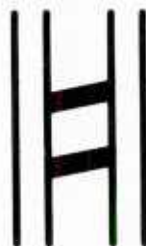
2330



2331



2332



2401

Π

2402

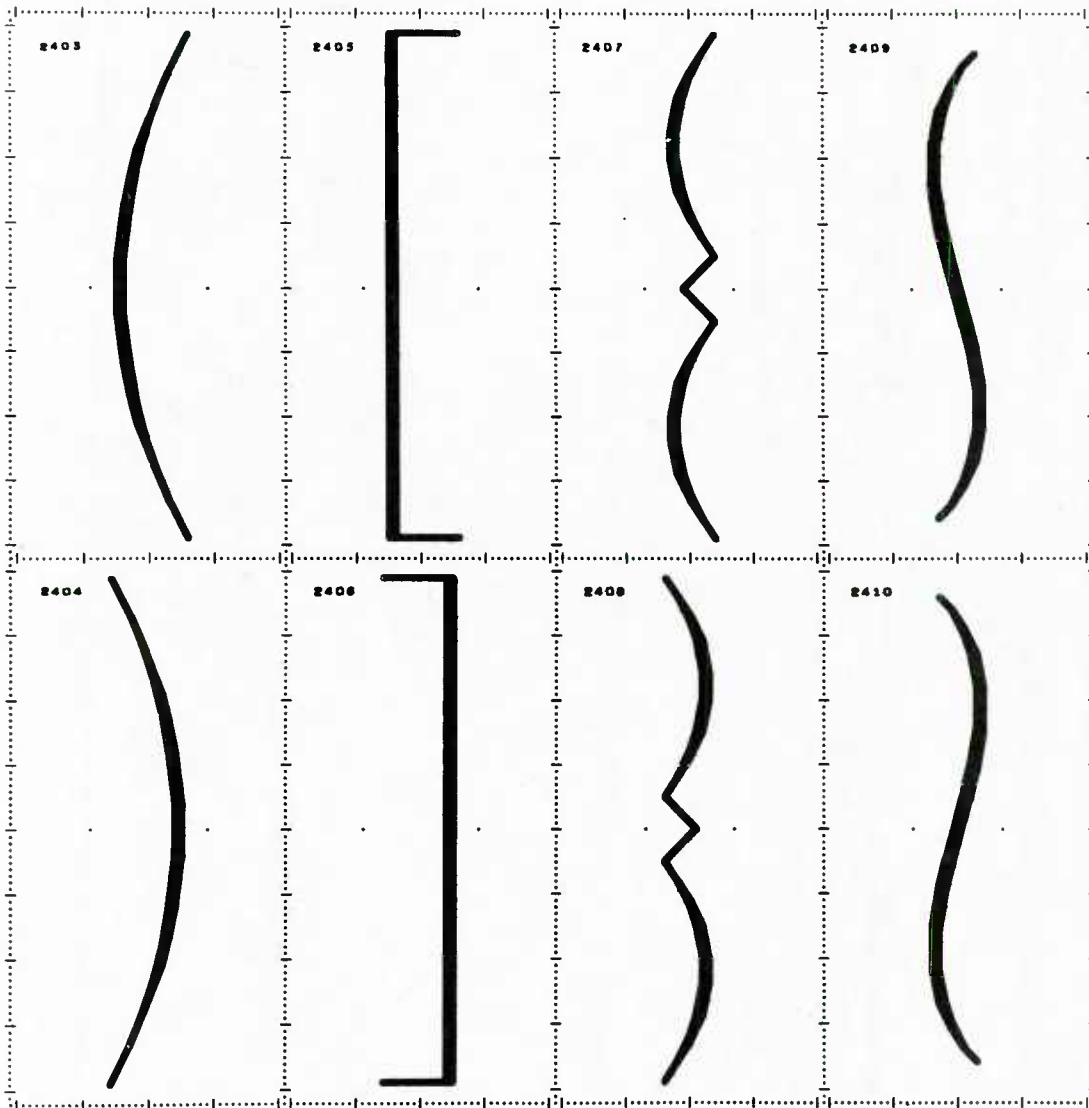
Σ

2411

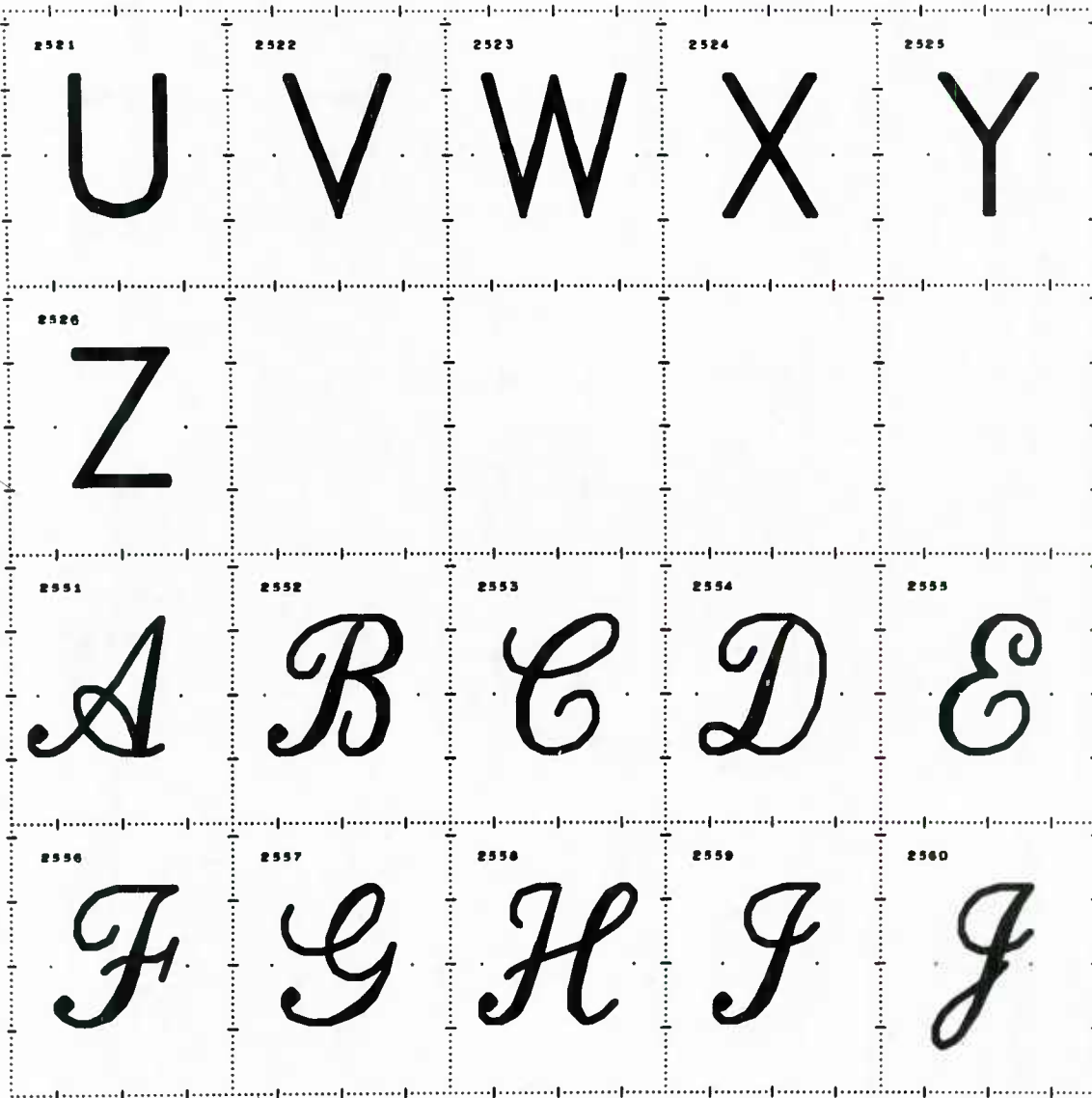
√

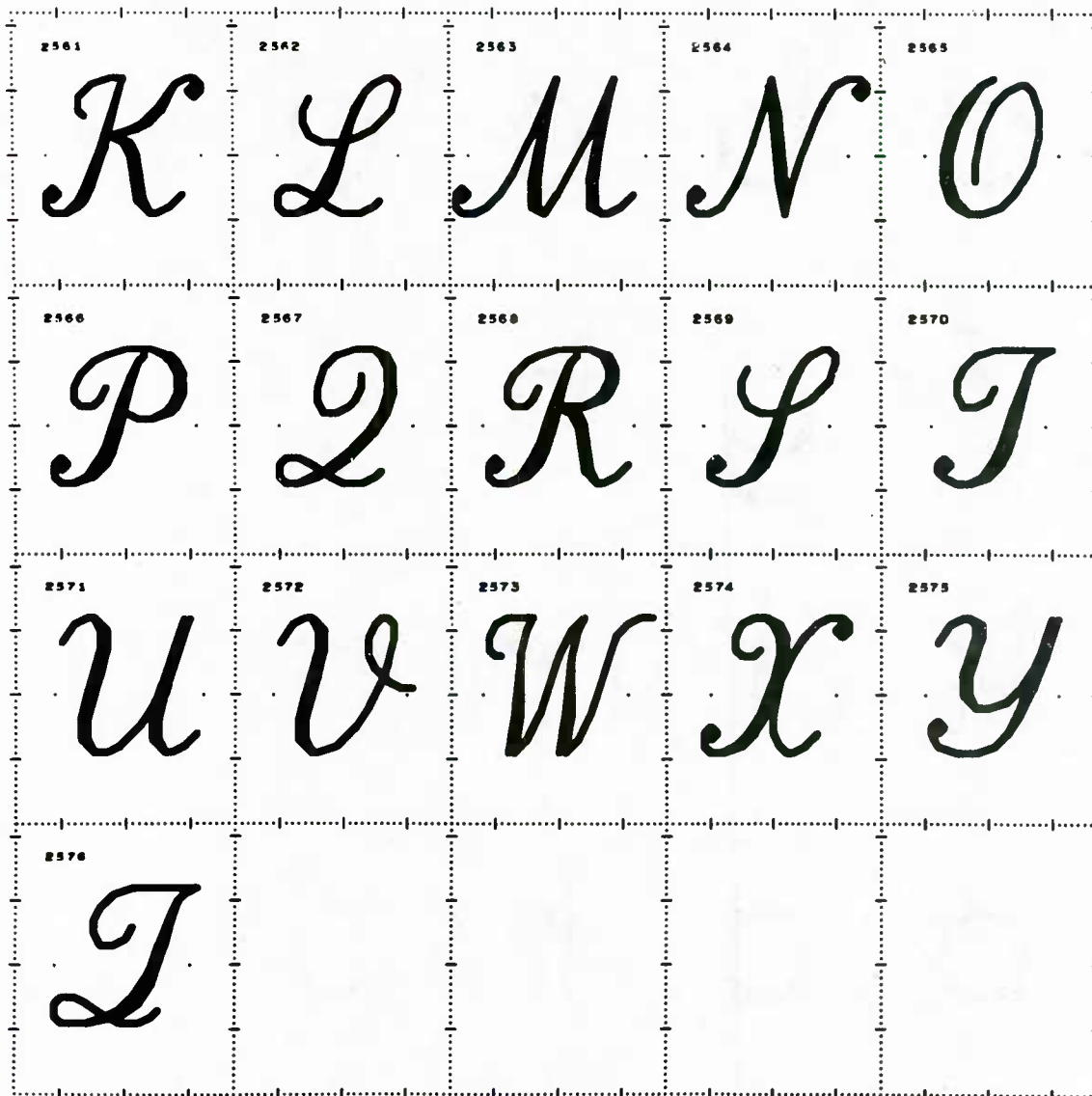
2412

∫



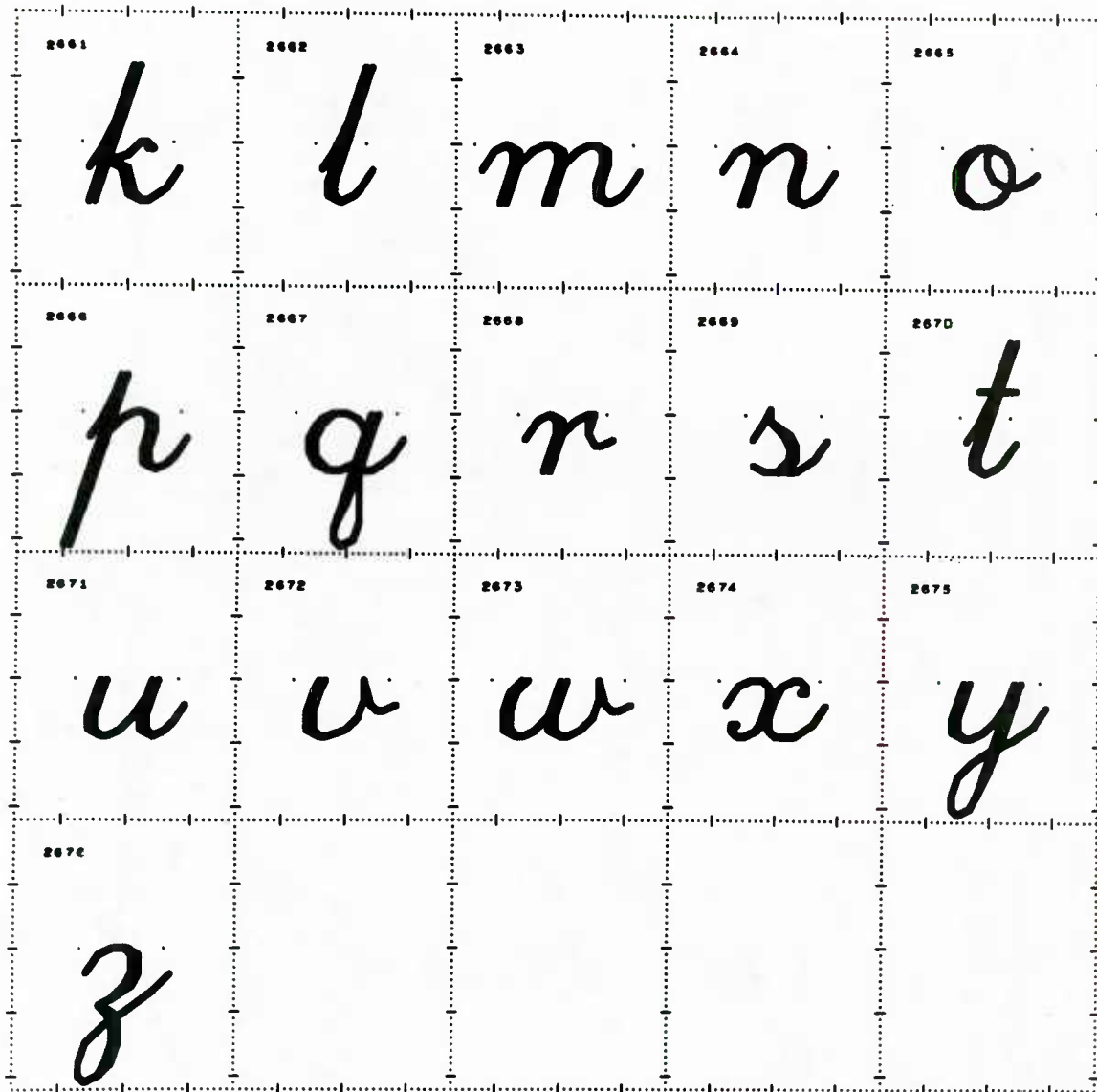
2501	2502	2503	2504	2505
A	B	C	D	E
2506	2507	2508	2509	2510
F	G	H	I	J
2511	2512	2513	2514	2515
K	L	M	N	O
2516	2517	2518	2519	2520
P	Q	R	S	T





2601	2602	2603	2604	2605
a	b	c	d	e
2606	2607	2608	2609	2610
f	g	h	i	i
2611	2612	2613	2614	2615
k	l	m	n	o
2616	2617	2618	2619	2620
p	q	r	s	t

2621	2622	2623	2624	2625
u	v	w	x	y
2626				
z				
2651	2652	2653	2654	2655
a	b	c	d	e
2656	2657	2658	2659	2660
f	g	h	i	j



2801 А	2802 Б	2803 В	2804 Г
2805 Д	2806 Е	2807 Ж	2808 З
2809 И	2810 Й	2811 К	2812 Л
2813 М	2814 Н	2815 О	2816 П

2017 Р	2018 С	2019 Т	2020 У
2021 Ф	2022 Х	2023 Ц	2024 Ч
2025 Ш	2026 Щ	2027 Ъ	2028 Ы
2029 Ь	2030 Э	2031 Ю	2032 Я

2901	2902	2903	2904
а	б	в	г
2905	2906	2907	2908
д	е	ж	з
2909	2910	2911	2912
и	й	к	л
2913	2914	2915	2916
м	н	о	п

2917	2918	2919	2920
р	с	т	у
2921	2922	2923	2924
ф	х	ц	ч
2925	2926	2927	2928
ш	щ	ъ	ы
2929	2930	2931	2932
ь	э	ю	я

PART III

TRIPLEX REPERTORY

- A. English Gothic
- B. Italian Gothic
- C. German Gothic

3001	3002	3003	3004	3005
A	𐌰	𐌱	𐌲	𐌳
3006	3007	3008	3009	3010
𐌴	𐌵	𐌶	𐌷	𐌸
3011	3012	3013	3014	3015
𐌹	𐌺	𐌻	𐌼	𐌽
3016	3017	3018	3019	3020
𐌾	𐌿	𐍀	𐍁	𐍂

3021

U

3022

V

3023

W

3024

X

3025

Y

3026

Z

3101

a

3102

b

3103

c

3104

d

3105

e

3106

f

3107

g

3108

h

3109

















i

3110

j

3111	3112	3113	3114	3115
k	l	m	n	o
3116	3117	3118	3119	3120
p	q	r	s	t
3121	3122	3123	3124	3125
u	v	w	x	y
3126				
z				

3201	3202	3203	3204	3205
A	B	C	D	E
3206	3207	3208	3209	3210
F	G	H	I	J
3211	3212	3213	3214	3215
K	L	M	N	O
3216	3217	3218	3219	3220
P	Q	R	S	T

3221	3222	3223	3224	3225
				
3226				
				
3301	3302	3303	3304	3305
				
3306	3307	3308	3309	3310
				

3311	3312	3313	3314	3315
k	l	m	n	o
3316	3317	3318	3319	3320
p	q	r	s	t
3321	3322	3323	3324	3325
u	v	w	x	y
3326				
z				

3401	3402	3403	3404	3405
U	B	E	D	F
3406	3407	3408	3409	3410
T	G	H	V	W
3411	3412	3413	3414	3415
K	L	M	N	O
3416	3417	3418	3419	3420
P	Q	R	S	X

3421

U

3422

V

3423

W

3424

X

3425

Y

3426

Z

3501

a

3502

b

3503

c

3504

d

3505

e

3506

f

3507

g

3508

h

3509

i

3510

j

3511	3512	3513	3514	3515
ƒ	l	m	n	o
3516	3517	3518	3519	3520
p	q	r	s	t
3521	3522	3523	3524	3525
u	v	w	x	y
3526	3527			
z	s			

APPENDIX C

DIGITALIZATION OF JAPANESE

DECK 2525

The border of each panel indicates the scale in raster units with every 10th raster unit accentuated. The number in the upper left corner is the number of the character. The words in the lower left corner are the *on* pronunciation for the *kanji* or the phonetic pronunciation for the *kana*.

PART I

KANJI LIST

0001 一 ICHI, ITSU	0007 万 MAN, BAN	0008 三 SAN	0009 下 KA, GE	0015 五 GO
0016 天 TEN	0017 不 FU, BU	0024 可 KOKU, KA	0026 平 HYŌ, BYŌ, HEI	0027 正 SEI, SHŌ
0033 百 BYAKU, HYAKU	0034 両 RYŌ	0035 再 SAI	0043 亜 A	0049 函 KAN
0050 画 GA, KAKU	0053 昼 CHŪ	0054 歪 WAI, E	0056 夏 GE, KA	0062 悪 O, AKU

0081

中

CHŪ

0082

内

DAI, NAi

0082

甲

KAN, KŌ

0086

本

HON

0097

出

SUI, SHUTSU

0101

向

KO, KYŌ

0103

曲

KYOKU

0107

果

KA

0108

表

HYŌ

0130

永

EI

0131

氷

HYŌ

0132

半

HAN

0138

為

I

0139

单

TAN

0146

九

KYŪ, KU

0154

及

KYŪ

0156

千

SEN

0162

午

GO

0166

少

SHŌ

0173

弗

FUTSU

0179 未 MI	0188 年 NEN	0195 系 KEI	0196 束 SOKU	0199 卯 RAN
0202 来 RAI	0211 垂 SUI	0213 東 TŌ	0223 乘 JŌ	0224 重 CHŌ, JŪ
0230 島 TŌ	0260 乙 ITSU, OTSU	0261 七 SHICHI	0272 事 JI	0273 二 NI, JI
0275 元 GAN, GEN	0283 六 RIKU, ROKU	0284 市 SHI	0285 主 SU, SHŪ, SHU	0290 交 KŌ

0298

夜

YA

0306

変

HEN

0319

率

SOTSU, RITSU

0321

商

SHŌ

0339

人

JIN, NIN

0350

化

KA, KE

0352

今

KIN, KON

0361

他

TA

0362

仕

SHI

0364

代

DAI

0383

合

GŌ

0384

全

ZEN

0401

位

I

0403

伸

SHIN

0405

体

TAI

0406

低

TEI

0407

作

SA, SAKU

0408

余

YO

0409

何

KA

0422

価

KA

0428 例 REI	0431 供 KYŌ, KU, GU	0449 係 KEI	0488 值 CHI	0509 側 SOKU
0511 偏 HEN	0534 傾 KEI	0540 像 ZŌ	0551 億 OKU	0571 先 SEN
0574 入 NYŪ, JU	0577 八 HATBU, HACHI	0578 分 BUN, FUN, BU	0579 公 KŌ, KU	0581 共 KYŌ
0588 典 TEN	0589 並 HEI	0590 其 KI	0595 前 SEN, ZEN	0617 円 EN

0619 同 DŌ	0622 周 SHŪ	0638 次 SHI, JI	0642 冷 REI	0665 刀 TŌ
0667 切 SETSU, SAI	0703 割 KATSU	0715 力 RIKI, RYOKU	0716 加 KA	0730 動 DŌ
0751 北 HOKU	0766 十 JŪ	0770 古 KO	0775 直 JIKI, CHOKU	0778 南 NAN
0783 真 SHIN	0790 幹 KAN	0791 準 JUN	0798 上 JŌ, SHŌ	0804 点 TEN

0817 反 HON. TAN. HAN	0818 压 EN. ATSU	0825 原 GEN	0855 又 YŪ	0859 双 SŌ
0888 口 KU. KŌ	0878 右 YŪ. U	0882 号 GŌ	0885 吸 KYŪ	0913 味 MI
0923 品 MIN. MON	0931 哲 TETSU	0973 嗅 KYŪ	0994 器 KI	1025 四 SHI
1026 因 IN	1028 回 E. KAI	1034 凶 TO. ZU	1036 固 KO	1037 国 KOKU

1043 圈 KEN	1050 土 TO, DO	1051 去 KYO, KO	1055 在 ZAI	1056 地 CHI, JI
1065 均 KIN	1077 型 KEI	1096 基 KI	1109 塔 TŌ	1113 場 JŌ
1125 塩 EN	1135 境 KYŌ, KEI	1137 増 ZŌ	1160 士 SHI	1161 冬 TŌ
1162 処 SHO	1163 各 KAKU	1167 夕 SEKI	1168 外 GE, GAI	1169 多 TA

1170 名 MYŌ, MEI	1171 大 TAI, DAI	1172 太 TAI, TA	1185 女 JO, NYO, NYŌ	1189 如 JO, NYO
1208 始 SHI	1264 子 SHI, SU	1267 存 SON, ZON	1271 学 GAKU	1280 宇 U
1281 字 JI	1291 宙 CHŪ	1296 定 TEI, JŌ	1297 実 JITSU	1300 室 SHITSU
1311 家 KA, KE	1316 密 MITSU	1322 寒 KAN	1334 導 DŌ	1355 小 SHŌ

1358 光 KŌ	1359 当 TŌ	1364 常 JŌ, SHŌ	1377 尺 SEKI, SHAKU	1383 尾 BI
1386 屈 KUTSU	1387 居 KO, KYO	1402 層 SŌ	1407 山 SAN	1418 炭 TAN
1431 嵐 RAN	1447 川 SEN	1451 工 KU, KŌ	1455 左 SA	1459 項 KŌ
1466 卷 KEN, KAN	1468 布 FU	1469 帆 HAN	1484 幅 FUKU	1492 干 KAN

1496 幾 KI	1504 応 ō	1506 底 TEI	1511 度 DO, TAKU, TO	1514 庭 TEI
1515 座 ZA	1556 式 SHIKI	1560 弓 KYŪ	1562 引 IN	1567 弧 KO
1568 弦 GEN	1571 強 KYŌ, GŌ	1575 彈 DAN	1582 帰 KI	1589 形 GYŌ, KEI
1598 役 EKI	1602 徑 KEI	1604 彼 HI	1610 後 GO, KŌ	1613 徙 SHŌ, JU, JŪ

1614 徒 TO	1621 術 JUTSU	1626 御 GO, GYO	1631 微 BI, MI	1636 衝 SHO
1641 衡 KŌ	1645 心 SHIN	1666 性 SEI, SHŌ	1683 恒 KŌ	1710 惑 WAKU
1728 想 SŌ	1731 感 KAN	1743 態 TAI	1756 慣 KAN	1794 戈 KA
1799 成 SEI, JŌ	1802 或 WAKU, KOKU	1817 戸 KO	1823 扇 SEN	1827 手 SHU

1855 折 SETSU	1885 押 ō	1903 持 JI	1904 指 SHI	1914 挺 TEI, CHŌ
1920 振 SHIN	1942 捩 REI, RETSU	1951 接 SETSU	1987 摘 TEKI	2039 支 SHI
2044 故 KO	2052 教 KYŌ	2056 散 SAN	2057 数 SAKU, SOKU, SU, SŪ	2064 文 MON, BUN
2067 对 TAI	2074 斜 SHA	2080 新 SHIN	2082 方 HŌ	2083 於 O

2084 放 HŌ	2097 日 JITSU, NICHİ, NITSU	2100 早 SA, SŌ, SATSU	2107 易 EKI, I	2108 昔 SHAKU, SEKI
2110 明 MEI, MYŌ, MIN	2119 昨 SAKU	2121 星 SEI, SHŌ	2122 春 SHUN	2126 時 JI
2137 晶 SHŌ	2138 暑 SHO	2141 量 RYŌ	2143 晴 SEI	2146 最 SAI
2154 暗 AN	2160 曇 DON	2164 題 DAI	2169 月 GETSU, GATSU	2170 木 BOKU, MOKU

2194 析 SEKI	2210 林 RIN	2211 枝 SHI, KI	2212 松 SHŌ	2233 柳 RYŪ
2236 柱 CHŪ	2241 相 SŌ, SHŌ	2254 核 KAU	2256 桜 Ō	2261 根 KON
2264 械 KAI	2301 森 SHIN	2303 植 SHOKU	2305 極 KYOKU, GOKU	2313 橇 DA
2324 楽 RAKU, GAKU	2343 構 KŌ	2359 標 HYŌ	2361 横 Ō	2376 橋 KYŌ

2379 機 KI	2412 欠 KETSU	2429 止 SHI	2430 此 SHI	2435 雌 SHI
2436 整 SEI	2438 列 RETSU	2439 死 SHI	2466 母 BO	2467 每 MAI
2470 比 HI	2473 毛 MŌ	2476 氏 SHI	2480 氣 KI, KE	2482 水 SUI
2503 沢 TAKU	2507 汽 KI	2509 決 KETSU	2529 波 HA	2530 河 KA

2534 油 YU, YŪ	2535 法 HŌ	2553 海 KAI	2565 涌 YŌ, YU	2573 酒 SHU
2576 流 RU, RYŪ	2589 液 EKI	2629 渦 KA	2631 湿 SHITSU	2632 測 SOKU
2634 温 ON	2637 減 GEN	2655 滝 RŌ, SŌ	2656 源 GEN	2659 溶 YŌ
2702 潮 CHŌ	2743 火 KO, KA	2745 灯 TEI, CHŌ, TŌ	2750 炉 RO	2770 然 ZEN, NEN

2772 焼 SHŌ	2773 無 MU, BU	2797 熱 NETSU	2807 燐 RIN	2808 燃 NEN
2829 愛 AI	2832 父 FU	2839 状 JŌ	2842 片 HEN	2848 牙 GA, GE
2852 牛 GO, GYŪ	2857 物 BUTSU, MOTSU	2860 特 TOKU	2868 犬 KEN	2922 王 Ō
2923 玉 GYOKU	2937 珪 KEI	2941 球 KYŪ	2942 理 RI	2943 現 GEN

2973 瓜 KA	2977 瓦 GA	2988 甘 KAN	2991 生 SHŌ, SEI	2993 用 YŌ
2994 田 DEN	2996 男 DAN, NAN	2998 界 KAI	3001 思 SHI	3008 異 I
3042 病 BYŌ, HEI	3092 発 HOTSU, HATSU	3095 白 HAKU, BYAKU	3097 的 TEKI	3109 皮 HI
3113 皿 BEI, MYŌ	3127 目 MOKU	3129 具 GU	3164 矛 MU, BŌ	3169 矢 SHI

3169

知

CHI

3172

短

TAN

3176

石

SEKI, SHAKU

3180

研

KEN

3191

硫

RYŪ

3192

硝

SHŌ

3200

硼

HŌ

3209

磁

JI

3228

示

JI, SHI

3264

利

RI

3265

私

SHI

3268

和

KA, WA

3271

秒

BYŌ

3272

科

KA

3273

秋

SHŪ

3275

秤

SHŌ

3280

称

SHŌ

3285

程

TEI

3294

稻

TŌ

3295

種

SHU

3306 積 SEKI	3313 穴 KETSU	3314 究 KYŪ	3317 空 KŪ	3325 窒 CHITSU
3343 立 RYŪ, RITSU	3366 竹 CHIKU	3385 第 TEI, DAI	3396 等 TŌ	3397 筆 HITSU
3415 算 SAN	3416 管 KAN	3458 籠 RŌ	3461 米 BEI, MAI	3468 料 RYŌ
3471 粒 RYŪ	3472 粘 NEN	3492 糸 SHI	3496 級 KYŪ	3509 純 JUN

3510

紙

SHI

3511

素

SO, SU

3520

組

SO

3521

終

SHŪ

3522

細

SAI

3523

経

KEI, KYŌ

3537

絵

KAI

3539

絶

ZETSU

3540

結

KETSU

3543

絹

KEN

3544

続

ZOKU

3567

総

SŌ

3579

緯

I

3580

線

SEN

3581

締

TEI

3597

縦

SHŌ, JŪ

3644

置

CHI

3656

羊

YŌ

3658

美

BI

3662

差

SHI, SA

3665 着 CHAKU	3673 羽 U	3676 翠 SUI	3690 翼 YOKU	3683 老 RŌ
3684 考 KŌ	3685 者 SHA	3697 耳 JI	3699 取 SHU	3719 書 SHO
3724 肉 NIKU	3727 有 YŪ, U	3749 胞 HŌ	3785 期 KI, GO	3786 朝 CHŌ
3837 臣 SHIN	3841 自 SHI, JI	3845 至 SHI	3855 舌 ZETSU	3856 乱 RAN, RON

3860 辞 JI	3863 舟 SHŪ	3865 般 HAN	3873 船 SEN	3881 良 RYŌ
3888 色 SHOKU, SHIKI	3909 花 KE, KA	3926 若 JAKU, NYA	3938 草 SŌ	3940 茶 SA, CHA
3958 荷 KA	3981 菊 KIKU	4001 葉 YŌ	4002 蒸 JŌ, SHŌ	4074 藥 YAKU
4109 虚 KYO, KO	4115 虫 CHŪ	4205 血 KETSU	4213 行 AN, KŌ, GYŌ	4214 衣 E, I

4234 装 SŌ, SHŌ	4255 複 FUKU	4273 西 SEI, SAI	4274 要 YŌ	4284 見 KEN, GEN
4301 角 KAKU	4306 解 GE, KAI	4309 言 GEN, GON	4312 計 KEI	4318 記 KI
4341 証 SHŌ	4358 話 WA	4374 語 GO, GYO	4375 讀 TOKU, DOKU	4384 誰 SUI
4391 論 RON	4458 谷 ROKU	4465 豆 TŌ, ZU	4472 象 SHŌ, ZŌ	4486 貝 BAI

4488

負

FU

4518

質

SHITSU

4534

赤

SEKI, SHAKU

4539

走

SŌ

4543

超

CHŌ

4546

足

SOKU

4548

距

KYO

4561

路

RO

4601

身

SHIN

4603

射

SHA

4608

車

SHA

4610

軌

KI

4615

転

TEN

4619

軸

JIKU

4620

輕

KEI

4623

較

KAKU, KŌ

4630

輪

RIN

4633

輻

FUKU

4646

辛

SHIN

4660

込

4661 辺 HEN	4671 近 KIN	4685 逆 GYAKU, GEKI	4700 速 SOKU	4701 造 ZŌ
4702 連 REN	4703 通 TSU, TŌ, TSŪ	4709 進 SHIN	4721 達 TATSU	4722 遅 CHI
4723 過 KA	4724 道 DŌ	4725 運 UN	4733 遠 EN, ON	4750 還 KAN, GEN
4789 酸 SAN	4798 醜 SHŪ	4809 积 SHAKU, SEKI	4811 番 BAN	4813 里 RI

4815

金

KON, KIN

4843

鉦

KŌ

4844

鉄

TETSU

4853

銅

DŌ

4855

銀

GIN

4883

鋼

KŌ

4938

長

CHŌ

4940

門

MON

4944

問

MON

4945

閉

HEI

4949

間

KAN

4950

開

KA I

4958

関

KAN

4959

聞

BUN, MON

4987

限

GEN

4993

除

JI, JO

4994

降

KŌ

5005

陸

ROKU, RIKU

5006

陰

ON, AN, IN

5012

陽

YŌ

5030 雄 YŪ	5038 難 NAN	5040 離 RI	5042 雨 U	5044 雪 SETSU
5046 雲 UN	5048 零 REI	5049 雷 RAI	5050 電 DEN	5055 震 SHIN
5056 靈 REI, RYŌ	5076 青 SEI, SHŌ	5077 靜 JŌ, SEI	5080 非 HI	5083 翡 HI
5087 面 MEN	5088 革 KAKU	5110 音 ON, IN	5138 類 RUI	5148 風 FU, FŪ

5152 飛 HI	5154 食 SHI, JIKI, SHOKU	5106 首 SHU	5100 香 KŌ	5101 馬 ME, BA, MA
5220 駢 KEN, GEN	5236 骨 KOTSU	5248 高 KŌ	5276 鬼 KI	5201 魚 GŌ
5340 鳥 CHŌ	5375 鹿 ROKU	5385 麦 BAKU	5390 麻 MA	5399 黄 KŌ, Ō
5403 黑 KOKU	5404 墨 BOKU	5415 鼓 KO	5421 鼻 BI	5426 齒 SHI

5440

竜

RYŪ, RYŌ

5443

亀

KI, KIN

6200

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6201

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6202

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PART II

HIRAGANA LIST

6000 あ A	6001 い I	6002 う U	6003 え E	6004 お O
6005 か KA	6006 き KI	6007 く KU	6008 け KE	6009 こ KO
6010 さ SA	6011 し SHI	6012 す SU	6013 せ SE	6014 そ SO
6015 た TA	6016 ち CHI	6017 つ TSU	6018 て TE	6019 と TO

6020 な NA	6021 に NI	6022 ぬ NU	6023 ね NE	6024 の NO
6025 は HA	6026 ひ HI	6027 ふ FU	6028 へ HE	6029 ほ HO
6030 ま MA	6031 み MI	6032 む MU	6033 め ME	6034 も MO
6035 や YA	6036 い YI	6037 ゆ YU	6038 え YE	6039 よ YO

6040 ら RA	6041 り RI	6042 る RU	6043 れ RE	6044 ろ RO
6045 わ WA	6046 ゐ WI	6047 う WU	6048 ゑ WE	6049 を WO
6050 ん N				
6055 が GA	6056 ぎ GI	6057 ぐ GU	6058 げ GE	6059 ご GO

6060 ざ	6061 じ	6062 ず	6063 ぜ	6064 ぞ
ZA	JI	ZU	ZE	ZO
6065 だ	6066 ぢ	6067 づ	6068 で	6069 ど
DA	JI	ZU	DE	DO
6070 ば	6071 び	6072 ぶ	6073 べ	6074 ぼ
BA	BI	BU	BE	BO
6075 ぱ	6076 ぴ	6077 ぷ	6078 ぺ	6079 ぽ
PA	PI	PU	PE	PO

PART III

KATAKANA LIST

6100 ア A	6101 イ I	6102 ウ U	6103 エ E	6104 オ O
6105 カ KA	6106 キ KI	6107 ク KU	6108 ケ KE	6109 コ KO
6110 サ SA	6111 シ SHI	6112 ス SU	6113 セ SE	6114 ソ SO
6115 タ TA	6116 チ CHI	6117 ツ TSU	6118 テ TE	6119 ト TO

6120 ナ NA	6121 ニ NI	6122 ヌ NU	6123 ネ NE	6124 ノ NO
6125 ハ HA	6126 ヒ HI	6127 フ FU	6128 ヘ HE	6129 ホ HO
6130 マ MA	6131 ミ MI	6132 ム MU	6133 メ ME	6134 モ MO
6135 ヤ YA	6136 イ YI	6137 ユ YU	6138 エ YE	6139 ヨ YO

6140 ラ RA	6141 リ RI	6142 ル RU	6143 レ RE	6144 ロ RO
6145 ワ WA	6146 ヰ WI	6147 ウ WU	6148 エ WE	6149 ヲ WO
6150 ン N				
6155 ガ GA	6156 ギ GI	6157 グ GU	6158 ゲ GE	6159 ゴ GO

6160 ザ ZA	6161 ジ JI	6162 ズ ZU	6163 ゼ ZE	6164 ゾ ZO
6165 ダ DA	6166 ヂ JI	6167 ヅ ZU	6168 デ DE	6169 ド DO
6170 バ BA	6171 ビ BI	6172 ブ BU	6173 ベ BE	6174 ボ BO
6175 パ PA	6176 ピ PI	6177 プ PU	6178 ペ PE	6179 ポ PO

APPENDIX D

LEXICON OF JAPANESE

GENGOGAKU

WA

WO

GA

TE

KA

YO

NO

NI

DE

TO

E

KARA

YORI

MADE

NI OITE

NI YOTTE

TO TOMO NI

USHIRO

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SHITA

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HIDARI

MIGI

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LINGUISTICS

NOMINATIVE PARTICLE

ACCUSATIVE PARTICLE

PREDICATIVE PARTICLE

SUBORDINATE PARTICLE

INTERROGATIVE PARTICLE

IMPERATIVE PARTICLE

OF

AT, IN

BY

WITH

TO

FROM

THAN

UNTIL

IN, AT

BY

WITH

BACK

FRONT

BOTTOM

TOP

LEFT

RIGHT

INSIDE

OUTSIDE

MIDDLE

SIDE

VICINITY

SPACE

TOKI	時	TIME
TAME	為	BEHALF
KAWARI	代り	EXCHANGE
KOCHIRA	こちら	HERE
SOCHIRA	そちら	THERE
ACHIRA	あちら	THERE
KOKO	此処	HERE
SOKO	其処	THERE
ASOKO	彼処	THERE
IMA	今	NOW
SONO TOKI	その時	THEN
DOKO	何処	WHERE
ITSU	何時	WHEN
NAZE	何故	WHY
IKAGA	如何	HOW
IKURA	幾ら	HOW MUCH
DONO KURAI	どの位	HOW FAR
NANBEN	何べん	HOW OFTEN
DŌ	どう	HOW
MOTTO	もつと	MORE
MOTTOMO	最も	MOST
DAKE	だけ	ONLY
DEMO	でも	EVEN
TAIHEN	大変	VERY
ŌKATA	大方	ALMOST
MŌ	もう	ALREADY
MADA	まだ	YET
MATA	又	AGAIN
AMARI	余り	TOO
KESSHITE	決して	NEVER

DOKOKA ^{DO} KA ^{KA}	何処か	SOMEWHERE
ITSUKA ^{ITSU} KA ^{KA}	何時か	SOMETIME
DŌKA ^{DO} KA ^{KA}	どうか	SOMEHOW
DOKODEMO ^{DO} KO ^{DO} DE ^{MO}	何処でも	ANYWHERE
ITSUDEMŌ ^{ITSU} DE ^{MO}	何時でも	ANYTIME
DŌDEMŌ ^{DO} DE ^{MO}	どうでも	ANYHOW
SHIJŪ ^{SHI} JŪ ^{JU}	始終	ALWAYS
SHITAGATTE ^{SHI} TA ^{GA} TE ^{TE}	従つて	THEREFORE
WATAKUSHI ^{WA} TA ^{KU} SHI ^{SHI}	私	I
ANATA ^{ANA} TA ^{TA}	あなた	YOU
ANO KATA ^{ANO} KATA ^{KATA}	あの方	HE, SHE
KARE ^{KARE}	彼	HE
KANOJO ^{KANO} JO ^{JO}	彼女	SHE
SORE ^{SORE}	其	IT
WATAKUSHITACHI ^{WA} TA ^{KU} SHI ^{SHI} TACHI ^{CHI}	私達	WE
ANATAGATA ^{ANA} TAGATA ^{GATA}	あなた方	YOU
ANO KATATACHI ^{ANO} KATATACHI ^{TACHI}	あの方達	THEY
KARERA ^{KARE} RA ^{RA}	彼等	THEY
KORE ^{KORE}	此	THIS
SORE ^{SORE}	其	THAT
ARE ^{ARE}	彼	THAT
KORERA ^{KORE} RA ^{RA}	此等	THESE
SORERA ^{SORE} RA ^{RA}	其等	THOSE
ARERA ^{KARE} RA ^{RA}	彼等	THOSE
DONATA ^{DONATA}	どなた	WHO
DOCHIRA ^{DOCHIRA}	どちら	WHICH
DARE ^{DARE}	誰	WHO
DORE ^{DORE}	どれ	WHICH
NANI ^{NANI}	何	WHAT
HŌ ^{HŌ}	方	ONE

KAKUJI	各自	EACH
RYŌHŌ	両方	BOTH
SUBETE	総て	ALL
IKURAKA	幾らか	SOME, ANY
DONATAKA	どなたか	SOMEONE
DAREKA	誰か	SOMEBODY
NANIKA	何か	SOMETHING
DONATAMO	どなたも	NO ONE
DAREMO	誰も	NOBODY
NANIMO	何も	NOTHING
DONATADEMO	どなたでも	EVERYONE
DAREDEMO	誰でも	EVERYBODY
NANDEMO	何でも	EVERYTHING
WATASHI NO	私の	MY
ANATA NO	あなたの	YOUR
ANO KATA NO	あの方の	HIS, HER
KARE NO	彼の	HIS
KANOJO NO	彼女の	HER
SONO	其の	ITS
WATAKUSHITACHI NO	私達の	OUR
ANATAGATA NO	あなた方の	YOUR
ANO KATATACHI NO	あの方達の	THEIR
KARERA NO	彼等の	THEIR
KONO	此の	THIS
SONO	其の	THAT
ANO	あの	THAT
KORERANO	此等の	THESE
SORERANO	其等の	THOSE
ARERANO	彼等の	THOSE
DONATA NO	どなたの	WHOSE

DOCHIRA NO	どちらの	WHICH
DARE NO	誰の	WHOSE
DONO	どの	WHICH
NANNO	何の	WHAT
HOKA NO	他の	OTHER
CHIISAI	小さい	SMALL
ŌKII	大きい	LARGE
HIKUI	低い	LOW
TAKAI	高い	HIGH
MIJIKAI	短い	SHORT
NAGAI	長い	LONG
HOSOI	細い	THIN
FUTOI	太い	THICK
CHIKAI	近い	NEAR
TŌI	遠い	FAR
FURUI	古い	OLD
ATARASHII	新しい	NEW
OSOI	遅い	SLOW
HAYAI	速い	FAST
KARUI	軽い	LIGHT
OMOI	重い	HEAVY
ATSUI	熱い	HOT
TSUMETAI	冷たい	COLD
KURAI	暗い	DARK
AKARUI	明るい	BRIGHT
WARUI	悪い	BAD
YOI	良い	GOOD
KATAI	難い	DIFFICULT
YASUI	易い	EASY
MINIKUI	醜い	UGLY

UTSUKUSHII

KARAI

AMAI

ATSUI

SAMUI

KUROI

SHIROI

AKAI

KIIROI

AOI

ARU

ONAJI

MUKAI

KARANO

MITSUNA

TSUNENO

INA

SEITEKI

DŌTEKI

JUNNA

TOKUSEINO

IPPANNO

OMONA

A-

CHŌ-

FU-

KATA-

FUKU-

KAKU-

MAI-

美しい

辛い

甘い

暑い

寒い

黒い

白い

赤い

黄いろい

青い

或る

同じ

向かい

空の

密な

常の

異な

静的

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特性の

一般の

主な

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毎

BEAUTIFUL

BITTER

SWEET

HOT

COLD

BLACK

WHITE

RED

YELLOW

BLUE, GREEN

SOME

SAME

OPPOSITE

EMPTY

DENSE

ORDINARY

STRANGE

STATIC

KINETIC

PURE

SPECIAL

GENERAL

PRINCIPAL

SUB-

SUPER-

NON-

ONE-WAY

TWO-WAY

EACH

EVERY

TAN-
TA-
BUN-
ZEN-
SAI-
DAI-
KA-
-KA
-TEKI
-SEI
-DAI
-RUI
MU
HAN
KŌ
OTSU
TSUI
SUKOŠHI
TAKUSAN
KAZU
ICHI
NI
SAN
SHI
GO
ROKU
SHICHI
HACHI
KU
JŪ

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全
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類
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甲
乙
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少
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山
数
一
二
三
四
五
六
七
八
九
十

SINGLE
MULTIPLE
PART
ALL
RE-
-TH
-ABLE
-ATION
-ICAL
-CITY
-SIZE
-LIKE
NOTHING
HALF
FORMER
LATTER
PAIR
FEW
MANY
NUMBER
ONE
TWO
THREE
FOUR
FIVE
SIX
SEVEN
EIGHT
NINE
TEN

HYAKU
SEN
MAN
OKU
HITOTSU
FUTATSU
MITSU
YOTSU
ITSUTSU
MUTSU
NANATSU
YATSU
KOKONOTSU
TŌ
TANI
MĒTORU
GURAMU
BYŌ
FUN
JI
HI
TSUKI
TOSHI
DAI
ASA
GOZEN
SHŌGO
GOGO
YŪGATA
HIRU

百
千
万
億
一つ
二つ
三つ
四つ
五つ
六つ
七つ
八つ
九つ
十
単位
米
瓦
秒
分
時
日
月
年
代
朝
午前
正午
午後
夕方
昼

HUNDRED
THOUSAND
TEN THOUSAND
HUNDRED MILLION
ONE
TWO
THREE
FOUR
FIVE
SIX
SEVEN
EIGHT
NINE
TEN
UNIT
METER
GRAM
SECOND
MINUTE
HOUR
DAY
MONTH
YEAR
AGE
MORNING
FORENOON
NOON
AFTERNOON
EVENING
DAY

YORU
KINŌ
KYŌ
ASHITA
HARU
NATSU
AKI
FUYU
MUKASHI
KAKO
GENZAI
MIRAI
EIEN
KAMI
HON
SUMI
FUDE
KAKU
JI
GŌ
SŪ
NA
GO
HYŌ
ZU
E
BUN
DAI
TEKIYŌ
ROMBUN

夜
昨日
今日
明日
春
夏
秋
冬
昔
過去
現在
未來
永遠
紙
本
墨
筆
画
字
号
数
名
語
表
図
絵
文
題
摘要
論文

NIGHT
YESTERDAY
TODAY
TOMORROW
SPRING
SUMMER
AUTUMN
WINTER
ANTIQUITY
PAST
PRESENT
FUTURE
ETERNITY
PAPER
BOOK
INK
BRUSH
STROKE
CHARACTER
SYMBOL
NUMERAL
NAME
WORD
TABLE
DIAGRAM
PICTURE
LITERATURE
TITLE
ABSTRACT
DISSERTATION

SHINBUN
JITEN
RAICHAKU
SHUPPATSU
YŌJI
SHISHUTSU
KŌTSŪ
RI
TETSUGAKU
IN
YŌ
KAI
RI
GENJITSU
RISŌ
KOTO
SHIN
HŌ
GENRI
KŌZON
FUHEN
SŌTAISEI
SHINKA
HI
SEI
KI
JUTSU
GENIN
KEKKA
MONDAI

新聞
辭典
來着
出發
用事
支出
交通
利
哲學
陰
陽
界
理
現實
理想
事
真
法
原理
恒存
不變
相對性
進化
非
正
機
術
原因
結果
問題

NEWSPAPER
DICTIONARY
ARRIVAL
DEPARTURE
BUSINESS
EXPENDITURE
TRAFFIC
ADVANTAGE
PHILOSOPHY
YIN
YANG
REALM
REASON
REAL
IDEAL
FACT
TRUTH
RULE
PRINCIPLE
CONSERVATION
INVARIANCE
RELATIVITY
EVOLUTION
WRONG
RIGHT
OPPORTUNITY
STRATAGEM
CAUSE
EFFECT
PROBLEM

KENKYŪ

JIKKEN

RIRON

HŌHŌ

SOKUTEI

KEISAN

HIKAKU

KAISHAKU

REIKAN

KŌBUTSUKAI

SHOKUBUTSUKAI

DŌBUTSUKAI

BIJUTSU

ONGAKU

KAGAKU

SHIZEN

ISHI

HISUI

KANE

HAGANE

KI

TAKE

ASA

KAWA

KINU

ZŌGE

SUMI

KŌ

SAKE

KUSURI

研究

実験

理論

方法

測定

計算

比較

解釈

靈感

鉞物界

植物界

動物界

美術

音楽

科学

自然

石

翡翠

金

鋼

木

竹

麻

革

絹

象牙

炭

香

酒

藥

RESEARCH

EXPERIMENT

THEORY

METHOD

MEASUREMENT

COMPUTATION

COMPARISON

INTERPRETATION

INSPIRATION

MINERAL KINGDOM

VEGETABLE KINGDOM

ANIMAL KINGDOM

ART

MUSIC

SCIENCE

NATURE

STONE

JADE

METAL

STEEL

WOOD

BAMBOO

HEMP

LEATHER

SILK

IVORY

CHARCOAL

INCENSE

RICE WINE

MEDICINE

ABURA
NENRYŌ
TSUCHI
KŌRI
MIZU
JŌKI
KŪKI
HI
TEN
TAI
MONO
MONO
KOKORO
JIBUN
KI
REI
AI
REI
KATA
KEI
MOTOI
KYŪ
HABA
KATA
IRO
MITSUDO
CHIKARA
KATA
HODO
SHŌ

油
燃料
土
氷
水
蒸氣
空氣
火
天
天体
物
者
心
自分
氣
靈
愛
例
型
系
基
級
幅
形
色
密度
力
方
程
性

OIL
FUEL
GROUND
ICE
WATER
STEAM
AIR
FIRE
SKY
BODY
OBJECT
PERSON
HEART
SELF
SPIRIT
SOUL
LOVE
EXAMPLE
MODEL
SYSTEM
BASIS
CLASS
WIDTH
SHAPE
COLOR
DENSITY
STRENGTH
MANNER
EXTENT
CHARACTER

DO	度	DEGREE
SHITSU	質	QUALITY
RYŌ	量	QUANTITY
TAISHŌ	对称	SYMMETRY
HANTAISHŌ	反对称	ANTISYMMETRY
TŌHŌSEI	等方性	ISOTROPY
IHŌSEI	異方性	ANISOTROPY
JŌTAI	状態	STATE
DŌTŌ	同等	EQUIVALENCE
HEIKŌ	平衡	EQUILIBRIUM
SHINKŪ	真空	VACUUM
KITAI	気体	GAS
EKITAI	液体	LIQUID
KOTAI	固体	SOLID
RYŪTAI	流体	FLUID
KESSHŌ	結晶	CRYSTAL
SŌCHI	装置	APPARATUS
JIKKENSHITSU	実験室	LABORATORY
CHIRIGAKU	地理学	GEOGRAPHY
IDO	緯度	LATITUDE
KEIDO	經度	LONGITUDE
KITA	北	NORTH
MINAMI	南	SOUTH
HIGASHI	東	EAST
NISHI	西	WEST
HOKKYOKU	北極	NORTH POLE
HOKKYOKUKEN	北極圈	ARCTIC CIRCLE
KITA KAIKISEN	北回帰線	TROPIC OF CANCER
SEKIDŌ	赤道	EQUATOR
MINAMI KAIKISEN	南回帰線	TROPIC OF CAPRICORN

NANKYOKUKEN

NANKYOKU

NIHON

AMERIKA

HOKUBEI

NANBEI

YŌROPPA

AFURIKA

AJIA

ŌSUTORARIA

CHŪGOKU

MINAMOTO

TAKI

KAWA

UMI

SHIMA

RIKU

TANI

YAMA

SAWA

TA

MICHI

HASHI

ZAI

SATO

SHI

KUNI

JINKŌ

MENSEKI

KISHŌGAKU

南極圈

南極

日本

亜米利加

北米

南米

ヨーロッパ

アフリカ

アジア

オーストラリア

中国

源

滝

川

海

島

陸

谷

山

沢

田

道

橋

在

里

市

国

人口

面積

気象学

ANTARCTIC CIRCLE

SOUTH POLE

JAPAN

AMERICA

NORTH AMERICA

SOUTH AMERICA

EUROPE

AFRICA

ASIA

AUSTRALIA

CHINA

SPRING

WATERFALL

RIVER

SEA

ISLAND

LAND

VALLEY

MOUNTAIN

SWAMP

RICE FIELD

ROAD

BRIDGE

COUNTRY

VILLAGE

CITY

COUNTRY

POPULATION

AREA

METEOROLOGY

TŌONSEN

TŌATSUSEN

RYŪTSŪ

TEIKIATSU

KŌKIATSU

ZENSEN

SORA

KUMO

SŌUN

SEKIUN

KENUN

KAZE

ARASHI

AME

YUKI

KAMINARI

INABIKARI

ONDOKEI

KIATSUKEI

SHITSUDOKEI

FŪSOKUKEI

KAGAKU

GENSO

KAGAKUKIGŌ

GENSHIBANGŌ

GENSHIRYŌ

GENSHIKA

GENSHI

BUNSHI

KI

等温線

等圧線

流通

低気圧

高気圧

前線

空

雲

層雲

積雲

巻雲

風

嵐

雨

雪

雷

稲光

温度計

気圧計

湿度計

風速計

化学

元素

化学記号

原子番号

原子量

原子価

原子

分子

基

ISOTHERM

ISOBAR

CIRCULATION

CYCLONE

ANTICYCLONE

FRONT

SKY

CLOUD

STRATUS CLOUD

CUMULUS CLOUD

CIRRUS CLOUD

WIND

STORM

RAIN

SNOW

THUNDER

LIGHTNING

THERMOMETER

BAROMETER

HYGROMETER

ANEMOMETER

CHEMISTRY

ELEMENT

CHEMICAL SYMBOL

ATOMIC NUMBER

ATOMIC WEIGHT

ATOMIC VALENCE

ATOM

MOLECULE

RADICAL

KAGŌBUTSU	化合物	COMPOUND
YŌEKI	溶液	SOLUTION
SŌ	相	PHASE
KETSUGŌ	結合	BOND
KŌZŌ	構造	STRUCTURE
SHIKI	式	FORMULA
HANNŌ	反応	REACTION
KANGEN	還元	REDUCTION
SANKA	酸化	OXIDATION
CHŪWA	中和	NEUTRALIZATION
KASUIBUNKAI	加水分解	HYDROLYSIS
DENKAI	電解	ELECTROLYSIS
BUNSEKI	分析	ANALYSIS
SŌGŌ	総合	SYNTHESIS
ENERUGĪ JUNI	エネルギー準位	ENERGY LEVEL
SUPIN RYŌSHISŪ	スピン量子数	SPIN QUANTUM NUMBER
KIDŌ RYŌSHISŪ	軌道量子数	ORBITAL QUANTUM NUMBER
SHURYŌSHISŪ	主量子数	PRINCIPAL QUANTUM NUMBER
SHŪKIKEI	周期系	PERIODIC SYSTEM
SUI SO	水素	HYDROGEN
HERIUMU	ヘリウム	HELIUM
RICHIMUMU	リチウム	LITHIUM
BERIRIUMU	ベリリウム	BERYLLIUM
HŌSO	硼素	BORON
TANSO	炭素	CARBON
CHISSO	窒素	NITROGEN
SANSO	酸素	OXYGEN
FUSSO	弗素	FLUORINE
NEON	ネオン	NEON
NATORIUMU	ナトリウム	SODIUM

MAGUNESHIUMU	マグネシウム	MAGNESIUM
ARUMINIUMU	アルミニウム	ALUMINUM
KEISO	珪素	SILICON
RIN	磷	PHOSPHORUS
IO	硫黄	SULPHUR
ENSO	塩素	CHLORINE
ARUGON	アルゴン	ARGON
KARIUMU	カリウム	POTASSIUM
KARUSHIUMU	カルシウム	CALCIUM
TETSU	鉄	IRON
DO	銅	COPPER
GIN	銀	SILVER
KIN	金	GOLD
MUKIKAGAKU	無機化学	INORGANIC CHEMISTRY
SAN	酸	ACID
ENKI	塩基	BASE
EN	塩	SALT
ION	イオン	ION
INION	陰イオン	ANION
YOION	陽イオン	CATION
ANMONIUMU	アンモニウム	AMMONIUM
SUISANKABUTSU	水酸化物	HYDROXIDE
FUKKABUTSU	弗化物	FLUORIDE
ENKABUTSU	塩化物	CHLORIDE
TANSANEN	炭酸塩	CARBONATE
SHOSANEN	硝酸塩	NITRATE
KEISANEN	珪酸塩	SILICATE
RINSANEN	磷酸塩	PHOSPHATE
RYUSANEN	硫酸塩	SULPHATE
ENSOSANEN	塩素酸塩	CHLORATE

YŪKIKAGAKU	有機化学	ORGANIC CHEMISTRY
TANKASUIISO	炭化水素	HYDROCARBON
ARUKŌRU	アルコール	ALCOHOL
ARUDEHIDO	アルデヒド	ALDEHYDE
SAN	酸	ACID
HAROGENKABUTSU	ハロゲン化物	HALIDE
SUISANKI	水酸基	HYDROXYL
AMINOKI	アミノ基	AMINO
MECHIRUKI	メチル基	METHYL
FENIRUKI	フェニル基	PHENYL
NITOROKI	ニトロ基	NITRO
KARUBONIRUKI	カルボニル基	CARBONYL
KARUBOKISHIRUKI	カルボキシル基	CARBOXYL
SHIANKABUTSU	シアン化物	CYANIDE
BUTSURIGAKU	物理学	PHYSICS
KIKŌ	機構	MECHANISM
ON	音	SOUND
NETSU	熱	HEAT
HIKARI	光	LIGHT
DENKI	電気	ELECTRICITY
JIKI	磁気	MAGNETISM
SHITSURYŌ	質量	MASS
NAGASA	長さ	LENGTH
JIKAN	時間	TIME
TENBIN	天秤	BALANCE
SHAKUDO	尺度	SCALE
TOKEI	時計	CLOCK
ICHI	位置	POSITION
HENI	変位	DISPLACEMENT
SOKUDO	速度	VELOCITY

KASOKUDO	加速度	ACCELERATION
SHITSUTEN	質点	PARTICLE
CHIKARA	力	FORCE
UNDŌRYŌ	運動量	MOMENTUM
SAYŌ	作用	ACTION
HANSAYŌ	反作用	REACTION
SHŌDŌ	衝動	IMPULSE
SHIGOTO	仕事	WORK
SHIGOTORITSU	仕事率	POWER
ICHI ENERUGĪ	位置エネルギー	POTENTIAL ENERGY
UNDŌ ENERUGĪ	運動エネルギー	KINETIC ENERGY
KOTAI RIKIGAKU	固体力学	SOLID DYNAMICS
SHITSURYŌ CHŪSHIN	質量中心	CENTER OF MASS
KANSEI MŌMENTO	慣性モーメント	MOMENT OF INERTIA
SENUNDŌRYŌ	線運動量	LINEAR MOMENTUM
KAKUNDŌRYŌ	角運動量	ANGULAR MOMENTUM
CHIKARA	力	FORCE
TORUKU	トルク	TORQUE
HIZUMI	歪	STRAIN
ŌRYOKU	応力	STRESS
DANSEI	弾性	ELASTICITY
TATENAMI	縦波	LONGITUDINAL WAVE
YOKONAMI	横波	TRANSVERSE WAVE
RYŪTAI RIKIGAKU	流体力学	FLUID DYNAMICS
SHIO	潮	TIDE
NAMI	波	WAVE
HAKŌ	波高	WAVE HEIGHT
HARETSU	波列	WAVE TRAIN
NAGARE	流れ	CURRENT
WAKIDASHI	湧き出し	SOURCE

SUIKOMI	吸い込み	SINK
RYŪSOKU	流束	FLUX
RYŪSEN	流線	STREAM LINE
KASEN	渦線	VORTEX LINE
KYOKAISŌ	境界層	BOUNDARY LAYER
KŌRYŪ	後流	WAKE
SŌRYŪ	層流	LAMINAR FLOW
RANRYŪ	乱流	TURBULENT FLOW
AONSOKURYŪ	亜音速流	SUBSONIC FLOW
CHŌONSOKURYŪ	超音速流	SUPERSONIC FLOW
NENDO	粘度	VISCOSITY
NETSURIKIGAKU	熱力学	THERMODYNAMICS
ATSURYOKU	圧力	PRESSURE
ONDO	温度	TEMPERATURE
TAISEKI	体積	VOLUME
ZETTAI REIDO	絶対零度	ABSOLUTE ZERO
ENERUGĪ	エネルギー	ENERGY
ENTARUPĪ	エンタルピー	ENTHALPY
ENTOROPĪ	エントロピー	ENTROPY
HINETSU	比熱	SPECIFIC HEAT
DENKIRIKIGAKU	電気力学	ELECTRODYNAMICS
DENKA	電荷	ELECTRIC CHARGE
JIKYOKU	磁極	MAGNETIC POLE
DENRYŪ	電流	ELECTRIC CURRENT
JISOKU	磁束	MAGNETIC FLUX
CHOKURYŪ	直流	DIRECT CURRENT
KORYŪ	交流	ALTERNATING CURRENT
DENI	電位	ELECTRIC POTENTIAL
JII	磁位	MAGNETIC POTENTIAL
JŌKYŌ	場強	FIELD INTENSITY

DENJŌ	電場	ELECTRIC FIELD
JIJŌ	磁場	MAGNETIC FIELD
DENDŌRYOKU	電動力	ELECTROMOTIVE FORCE
JIDŌRYOKU	磁動力	MAGNETOMOTIVE FORCE
DŌDENSEI	導電性	CONDUCTIVITY
KAIRO	回路	CIRCUIT
CHOKURETSU	直列	SERIES
HEIRETSU	並列	PARALLEL
DENRYŪKEI	電流計	AMMETER
DENATSUKEI	電圧計	VOLTMETER
DENJIFUKUSHA	電磁輻射	ELECTROMAGNETIC RADIATION
KŌSOKU	光速	VELOCITY OF LIGHT
HANSHA	反射	REFLECTION
KUSSETSU	屈折	REFRACTION
KAISETSU	回折	DIFFRACTION
HENKŌ	偏光	POLARIZATION
KŌSEN	光線	LIGHT RAY
JŌKŌSEN	常光線	ORDINARY RAY
IJŌKŌSEN	異常光線	EXTRAORDINARY RAY
ZŌ	像	IMAGE
JITSUZŌ	実像	REAL IMAGE
KYOZŌ	虚像	VIRTUAL IMAGE
HAMEN	波面	WAVE FRONT
SHINPUKU	振幅	AMPLITUDE
ISŌ	位相	PHASE
SHŪHASŪ	周波数	FREQUENCY
HACHŌ	波長	WAVE LENGTH
SHŪKI	周期	PERIOD
HASŪ	波数	WAVE NUMBER
KŌDO	光度	INTENSITY

BUNKŌ	分光	SPECTRUM
KAKUBUTSURIGAKU	核物理学	NUCLEAR PHYSICS
RYŌSHI	量子	QUANTUM
KŌSHI	光子	PHOTON
CHŪSEIBISHI	中性微子	NEUTRINO
DENSHI	電子	ELECTRON
YŌDENSHI	陽電子	POSITRON
CHŪKANSHI	中間子	MESON
CHŪSEISHI	中性子	NEUTRON
YŌSHI	陽子	PROTON
JŪYŌSHI	重陽子	DEUTERON
SANJŪSHI	三重子	TRITON
KAKUSHU	核種	NUCLIDE
KAKU	核	NUCLEUS
RYŪSHI	粒子	PARTICLE
HANRYŪSHI	反粒子	ANTIPARTICLE
KAKUHANNŌ	核反応	NUCLEAR REACTION
GENSHIRO	原子炉	ATOMIC PILE
TEMMONGAKU	天文学	ASTRONOMY
SEKI	赤緯	DECLINATION
SEKIKEI	赤經	RIGHT ASCENSION
TŌKYŪ	等級	MAGNITUDE
TAIYŌ	太陽	SUN
TSUKI	月	MOON
WAKUSEI	惑星	PLANET
SUISEI	水星	MERCURY
KINSEI	金星	VENUS
CHIKYŪ	地球	EARTH
KASEI	火星	MARS
MOKUSEI	木星	JUPITER

DOSEI	土星	SATURN
TENNŌSEI	天王星	URANUS
KAIŌSEI	海王星	NEPTUNE
HOSHI	星	STAR
SEIZA	星座	CONSTELLATION
GINGA	銀河	GALAXY
UCHŪ	宇宙	UNIVERSE
GESSHOKU	月食	LUNAR ECLIPSE
NISSHOKU	日食	SOLAR ECLIPSE
GENGETSU	弦月	CRESCENT MOON
KIDŌ	軌道	ORBIT
KINCHITEN	近地点	PERIGEE
ENCHITEN	遠地点	APOGEE
KINJITSUTEN	近日点	PERIHELION
ENJITSUTEN	遠日点	APHELION
JŪRYOKUSAYŌ	重力作用	GRAVITATION
SŪGAKU	数学	MATHEMATICS
SŪCHI KAISEKIGAKU	数值解析学	NUMERICAL ANALYSIS
SEISŪ	正数	POSITIVE NUMBER
FUSŪ	負数	NEGATIVE NUMBER
ATAI	値	VALUE
ZETTAICHI	絶対値	ABSOLUTE VALUE
SŌTAICHI	相對値	RELATIVE VALUE
RITSU	率	MODULUS
KEISŪ	係数	COEFFICIENT
HI	比	RATIO
KIGŌ KAISEKIGAKU	記号解析学	SYMBOLICAL ANALYSIS
KAGŌ	加号	ADDITION SIGN
GENGŌ	減号	SUBTRACTION SIGN
JŌGŌ	乗号	MULTIPLICATION SIGN

JOGŌ	除号	DIVISION SIGN
TŌGŌ	等号	EQUALITY SIGN
KONGŌ	根号	RADICAL SIGN
WA	和	SUM
SA	差	DIFFERENCE
SEKI	積	PRODUCT
SHŌ	商	QUOTIENT
BUNSHI	分子	NUMERATOR
BUNBO	分母	DENOMINATOR
HŌTEISHIKI	方程式	EQUATION
FUTŌSHIKI	不等式	INEQUALITY
SANJUTSU	算術	ARITHMETIC
SEISŪ	整数	INTEGER
BUNSŪ	分数	FRACTION
SOKO	底	BASE
SHISŪ	指数	INDEX
GYAKUSŪ	逆数	RECIPROCAL
TAISŪ	对数	LOGARITHM
SHINSŪ	真数	ANTILOGARITHM
SŌKEI	総計	TOTAL
HEIKIN	平均	MEAN
KAHŌ	加法	ADDITION
GENPŌ	減法	SUBTRACTION
JŌHŌ	乘法	MULTIPLICATION
JOHŌ	除法	DIVISION
KAIHŌ	解法	SOLUTION
KŌSHIKIKA	公式化	FORMULATION
KŌSŌ	構想	PLAN
BANGUMI	番組	PROGRAM
ANGŌ	暗号	CODE

KEISANKI
SANKAKUHŌ
SEIGEN
YOGEN
SEISETSU
YOSETSU
SEIKATSU
YOKATSU
GYAKUSEIGEN
GYAKUSEISETSU
DAISŪGAKU
JŌ
NIJŌ
SANJŌ
KONSŪ
HEIHŌKON
RIPPŌKON
ISŪ
DAICHII
DAINII
DAISANI
JISŪ
ICHIJI
NIJI
SANJI
KŌ
IN
SHIKI
TAKŌSHIKI
KYŪSŪ

計算器
三角法
正弦
余弦
正切
余切
正割
余割
逆正弦
逆正切
代数学
乗
二乗
三乗
根数
平方根
立方根
位数
第一位
第二位
第三位
次数
一次
二次
三次
項
因
式
多項式
級数

CALCULATOR
TRIGONOMETRY
SINE
COSINE
TANGENT
COTANGENT
SECANT
COSECANT
ARCSINE
ARCTANGENT
ALGEBRA
POWER
SQUARE
CUBE
ROOT
SQUARE ROOT
CUBE ROOT
ORDER
FIRST
SECOND
THIRD
DEGREE
LINEAR
QUADRATIC
CUBIC
TERM
FACTOR
EXPRESSION
POLYNOMIAL
SERIES

YŌSO
GYŌRETSU
GYŌRETSUSHIKI
KOYŪ
HEISHIN
KAITEN
HANTEN
DŌRAI
RISSHŌ
BIBUNGAKU
DŌKANSŪ
JŌDŌKANSŪ
HENDŌKANSŪ
ZENDŌKANSŪ
SEKIBUNGAKU
SEKIBUN
FUTEISEKIBUN
DAENSEKIBUN
SENSEKIBUN
MENSEKIBUN
TAISEKIBUN
KAISEKIGAKU
JISSŪ
KYOSŪ
FUKUSOSŪ
KYŌYAKU
HENKA
RENZOKU
TOKUI
GENDO

要素
行列
行列式
固有
並進
回轉
反轉
導来
立証
微分学
導函数
常導函数
偏導函数
全導函数
積分学
積分
不定積分
楕円積分
線積分
面積分
体積分
解析学
実数
虚数
複素数
共役
変化
連続
特異
限度

ELEMENT
MATRIX
DETERMINANT
CHARACTERISTIC
TRANSLATION
ROTATION
INVERSION
DERIVATION
PROOF
DIFFERENTIAL CALCULUS
DERIVATIVE
ORDINARY DERIVATIVE
PARTIAL DERIVATIVE
TOTAL DERIVATIVE
INTEGRAL CALCULUS
INTEGRAL
INDEFINITE INTEGRAL
ELLIPTIC INTEGRAL
LINE INTEGRAL
SURFACE INTEGRAL
VOLUME INTEGRAL
ANALYSIS
REAL NUMBER
IMAGINARY NUMBER
COMPLEX NUMBER
CONJUGATE
VARIATION
CONTINUITY
SINGULARITY
LIMIT

REI
ENSHŪRITSU
MUGENDAI
TEISŪ
HENSŪ
KANSŪ
GYAKUKANSŪ
TŌSA KYŪSŪ
TŌHI KYŪSŪ
DAISŪKANSŪ
SANKAKUKANSŪ
SŌKYOKUKANSŪ
TAISŪKANSŪ
SHISŪKANSŪ
BESSERU KANSŪ
KIKAGAKU
TEN
SEN
HYŌMEN
RITTAI
CHOKUSEN
CHIHEISEN
SHASEN
SUICHOKUSEN
CHOKURITSUSEN
HEIKŌSEN
SUISEN
HEN
KADO
SHAHEN

零
円周率
無限大
定数
変数
函数
逆函数
等差級数
等比級数
代数函数
三角函数
双曲函数
对数函数
指数函数
ベツセル函数
幾何学
点
線
表面
立体
直線
地平線
斜線
垂直線
直立線
平行線
垂線
辺
角
斜辺

ZERO
PI
INFINITY
CONSTANT
VARIABLE
FUNCTION
INVERSE FUNCTION
ARITHMETIC SERIES
GEOMETRIC SERIES
ALGEBRAIC FUNCTION
TRIGONOMETRIC FUNCTION
HYPERBOLIC FUNCTION
LOGARITHMIC FUNCTION
EXPONENTIAL FUNCTION
BESSEL FUNCTION
GEOMETRY
POINT
LINE
SURFACE
SOLID
STRAIGHT LINE
HORIZONTAL LINE
OBLIQUE LINE
VERTICAL LINE
VERTICAL LINE
PARALLEL LINES
PERPENDICULAR LINES
SIDE
CORNER
HYPOTENUSE

SHAKAKU	斜角	OBLIQUE ANGLE
CHOKKAKU	直角	RIGHT ANGLE
HEIKAKU	平角	STRAIGHT ANGLE
SANKAKUKEI	三角形	TRIANGLE
SEIHŌKEI	正方形	SQUARE
HEIKŌSHIHENKEI	平行四辺形	PARALLELOGRAM
KYOKUSEN	曲線	CURVE
SESSEN	接線	TANGENT
HŌSEN	法線	NORMAL
KYOKURITSU	曲率	CURVATURE
KŌTEN	交点	INTERSECTION
EN	円	CIRCLE
CHŪSHIN	中心	CENTER
HANKEI	半径	RADIUS
CHOKKEI	直径	DIAMETER
GEN	弦	CHORD
KO	弧	ARC
ENSHŪ	円周	CIRCUMFERENCE
DAEN	橢円	ELLIPSE
HŌBUTSUSEN	放物線	PARABOLA
SŌKYOKUSEN	双曲線	HYPERBOLA
RETSU	列	ROW
SŌ	層	LAYER
HEIMEN	平面	PLANE
RIPPŌTAI	立方体	CUBE
CHŪ	柱	CYLINDER
KYŪ	球	SPHERE
GENTEN	原点	ORIGIN
ZAHYŌ	座標	COORDINATE
ŌZAHYŌ	横座標	ABSCISSA

JŪZAHYŌ	縦座標	ORDINATE
HEIKŌZAHYŌ	平行座標	CARTESIAN COORDINATES
HŌKŌ	方向	DIRECTION
KYORI	距離	DISTANCE
KYOKUZHAYŌ	極座標	POLAR COORDINATES
SEIBUN	成分	COMPONENT
JIGEN	次元	DIMENSION
KŪKĀN	空間	SPACE
SOKURYŌ	測量	METRIC
SOKUCHI	測地	GEODESIC
SUKARĀ	スカラー	SCALAR
BEKUTORU	ベクトル	VECTOR
TENSORU	テンソル	TENSOR
POTENSHARU	ポテンシャル	POTENTIAL
SŪRYŌSEKI	数量積	SCALAR PRODUCT
HŌKŌRYŌSEKI	方向量積	VECTOR PRODUCT
KEIDO	傾度	GRADIENT
HASSAN	発散	DIVERGENCE
KAITEN	回転	CURL
SEIBUTSUGAKU	生物学	BIOLOGY
SEI	生	LIFE
SHI	死	DEATH
SEI	性	SEX
OSU	雄	MALE
MESU	雌	FEMALE
SHU	種	SPECIES
KA	科	FAMILY
SAIBŌ	細胞	CELL
SHOKUBUTSUGAKU	植物学	BOTANY
NE	根	ROOT

MIKI
EDA
HA
HANA
TANE
KI
HAYASHI
MORI
MATSU
SAKURA
YANAGI
URI
INE
KOME
MAME
MUGI
CHA
KUSA
KIKU
DÖBUTSUGAKU
CHI
HONE
NIKU
KAWA
KE
HANE
HA
KIBA
YUBI
SHITA

幹
枝
葉
花
種
木
林
森
松
桜
柳
瓜
稻
米
豆
麦
茶
草
菊
動物学
血
骨
肉
皮
毛
羽
齒
牙
指
舌

TRUNK
BRANCH
LEAF
FLOWER
SEED
TREE
GROVE
FOREST
PINE
CHERRY
WILLOW
MELON
RICE PLANT
RICE
BEANS
WHEAT
TEA
GRASS
CHRYSANTHEMUM
ZOOLOGY
BLOOD
BONE
FLESH
SKIN
HAIR
FEATHER
TOOTH
TUSK
FINGER
TONGUE

TE
ASHI
YOKU
O
KUBI
ME
MIMI
HANA
KUCHI
MI
TAMAGO
MUSHI
KAME
KAI
SAKANA
TORI
INU
HITSUJI
USHI
UMA
SHIKA
ZŌ
ONI
TATSU
JINRUIGAKU
HITO
OTOKO
ONNA
KO
CHICHI

手
足
翼
尾
首
目
耳
鼻
口
身
卵
虫
亀
貝
魚
鳥
犬
羊
牛
馬
鹿
象
鬼
竜
人類学
人
男
女
子
父

HAND
FOOT
WING
TAIL
HEAD
EYE
EAR
NOSE
MOUTH
BODY
EGG
INSECT
TURTLE
SHELLFISH
FISH
BIRD
DOG
SHEEP
COW
HORSE
DEER
ELEPHANT
DEMON
DRAGON
ANTHROPOLOGY
MAN
MAN
WOMAN
CHILD
FATHER

HAHA

UJI

SHIN

KŌ

SHI

Ō

BIJUTSUKA

KAGAKUSHA

SEITO

SENSEI

KUMI

ITO

NUNO

KOROMO

ŌGI

KAGO

TABA

SHINA

SARA

UTSUWA

TAMA

TŌ

TSUZUMI

KATANA

HOKO

MU

YUMI

YA

MATO

ANA

母氏臣工士王美術家
科学者生徒先生
組糸布衣扇籠束品皿器玉灯鼓刀戈矛弓矢的穴

MOTHER

FAMILY

RETAINER

ARTISAN

WARRIOR

KING

ARTIST

SCIENTIST

STUDENT

TEACHER

CLASS

THREAD

CLOTH

CLOTHES

FAN

BASKET

BUNDLE

ARTICLE

DISH

VESSEL

GEM

LAMP

DRUM

SWORD

HALBERD

SPEAR

BOW

ARROW

TARGET

HOLE

BA
NI
KUBIKI
KURUMA
HO
HANSEN
TO
IE
TŌRŌ
NIWA
MON
HYŌ
TŌ
TORII
KŌGAKU
KŌGU
TEKO
JIKU
YA
RIN
KUDA
KIKAI
KIKAN
JIDŌSHA
RĚSSHA
TETSUDŌ
KOBUNE
KISEN
SUIJŌKI
HIKŌKI

場
荷
衡
車
帆
帆船
戸
家
灯籠
庭
門
標
塔
鳥居
工学
工具
挺子
軸
輻
輪
管
機械
機関
自動車
列車
鐵道
小舟
汽船
水上機
飛行機

PLACE
LOAD
YOKE
VEHICLE
SAIL
SAILBOAT
DOOR
HOUSE
LANTERN
GARDEN
GATE
MARKER
TOWER
GATEWAY
ENGINEERING
TOOL
LEVER
AXLE
SPOKE
WHEEL
PIPE
MACHINE
ENGINE
AUTOMOBILE
TRAIN
RAILWAY
SMALL CRAFT
STEAMSHIP
HYDROPLANE
AEROPLANE

TĀBIN	タービン	TURBINE
HATSUDENKI	発電機	GENERATOR
DENRYOKUSEN	電力線	POWER LINE
HENATSUKI	変圧器	TRANSFORMER
KAIHEIKI	開閉器	SWITCH
DENTŌ	電灯	ELECTRIC LIGHT
DENSHIKAN	電子管	ELECTRON TUBE
TORANJISUTĀ	トランジスター	TRANSISTOR
DENWA	電話	TELEPHONE
TEREBIJON	テレビジョン	TELEVISION
DENJISHAKU	電磁石	ELECTROMAGNET
DENDŌKI	電動機	MOTOR
ZŌFUKUKI	増幅器	AMPLIFIER
HASSHINKI	発振器	OSCILLATOR
IRU, ORU	居る	BE
ARU	有る	BE
DESU	です	BE
GOZARU	御座る	BE
HAJIMARU	始まる	START
TOMARU	止まる	STOP
TSUZUKU	続く	CONTINUE
OWARU	終る	END
KAWARU	変る	CHANGE
NARU	成る	BECOME
KURU	来る	COME
IKU, YUKU	行く	GO
KUDARU	下る	GO DOWN
AGARU	上がる	GO UP
HAIRU	入る	GO IN
DERU	出る	GO OUT

TÔRU	通る	GO THROUGH
MAWARU	回る	GO AROUND
SUGIRU	過ぎる	GO BY
TATSU	立つ	STAND UP
KAERU	帰る	RETURN
SARU	去る	LEAVE
ITARU	至る	REACH
HERU	減る	DECREASE
MASU	増す	INCREASE
AU	合う	AGREE
HANARERU	離れる	SEPARATE
CHIRU	散る	DISPERSE
SHIMARU	締まる	CLOSE
AKU	明く	OPEN
UGOKU	動く	MOVE
TENJIRU	転じる	TURN
TARERU	垂れる	HANG
KATAMUKU	傾く	TILT
NOBIRU	伸びる	STRETCH
MAGARU	曲る	BEND
NEJIRERU	捩れる	TWIST
WARERU	割れる	CRACK
ORERU	折れる	BREAK
AMARU	余る	REMAIN
TSUMORU	積もる	ACCUMULATE
MUSU	蒸す	STEAM
YAKERU	焼ける	BURN
MOERU	燃える	BURN
HASHIRU	走る	RUN
TOBU	飛ぶ	FLY

FURU	降る	FALL
FURU	振る	SWING
FURUERU	震える	QUAKE
HAZUMU	弾む	SPRING
NAGARERU	流れる	FLOW
SUU	吸う	FLOW IN
WAKU	涌く	FLOW OUT
HIKARU	光る	SHINE
KUMORU	曇る	CLOUD UP
HARERU	晴れる	CLEAR UP
HENSURU	偏する	BE BIASED
KANSURU	関する	BE CONNECTED
UMARERU	生れる	BE BORN
HAERU	生える	GROW
YAMU	病む	BECOME ILL
NAORU	直る	BECOME WELL
OIRU	老いる	BECOME OLD
SHINU	死ぬ	DIE
SURU	為る	DO
MOCHIIRU	用いる	USE
MOTSU	持つ	HOLD
YŪSURU	有する	HAVE
HAJIMERU	始める	START
TOMERU	止める	STOP
TSUZUKERU	続ける	CONTINUE
OERU	終える	END
KAERU	変える	CHANGE
NASU	成す	ACHIEVE
HIKU	引く	PULL
OSU	押す	PUSH

KUDASARU

AGERU

IRERU

DASU

TŌSU

MAWASU

SUGOSU

TATERU

KISURU

SARU

KAWARU

HERASU

MASU

AWASERU

HANASU

CHIRASU

SHIMERU

AKERU

UGOKASU

TENJIRU

TARASU

KATAMUKERU

NOBASU

MAGERU

NEJIRU

WARU

ORU

AMASU

TSUMU

MUSU

下さる

上げる

入れる

出す

通す

回す

過ごす

立てる

帰する

去る

代る

減らす

増す

合わせる

離す

散らす

締める

明ける

動かす

転じる

垂らす

傾ける

伸ばす

曲げる

振る

割る

折る

余す

積む

蒸す

GIVE

GIVE

PUT IN

PUT OUT

SEND THROUGH

SEND AROUND

SPEND

SET UP

ATTRIBUTE

LEAVE

REPLACE

DECREASE

INCREASE

UNITE

SEPARATE

DISPERSE

CLOSE

OPEN

MOVE

TURN

HANG

TILT

STRETCH

BEND

TWIST

CRACK

BREAK

LEAVE

ACCUMULATE

STEAM

YAKU

MOYASU

TSUKURU

KAMAERU

KAKU

YŌSURU

TSUMU

SASAERU

HOSU

SHIMESU

ASSURU

MAKU

MUSUBU

TORU

OKU

HAKOBU

HŌRU

IRU

ATARU

KIRU

KAWASU

HANASU

HANSURU

MICHIBIKU

SHITAGAU

HAKARU

KURABERU

TABERU

MIRU

KIKU

焼く

燃やす

造る

構える

欠く

要する

摘む

支える

干す

湿す

圧する

巻く

結ぶ

取る

置く

運ぶ

放る

射る

当る

切る

交す

放す

反する

導く

従う

計る

比べる

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EXCHANGE

RELEASE

OPPOSE

LEAD

FOLLOW

MEASURE

COMPARE

EAT

SEE

HEAR

KAGU	嗅ぐ	SMELL
AJIWAW	味わう	TASTE
SESSURU	接する	TOUCH
KANJIRU	感じる	FEEL
KIRU	着る	WEAR
KISERU	着せる	DRESS
RYŌRI SURU	料理する	COOK
IU, YUU	言う	SPEAK
KAKU	書く	WRITE
YOMU	読む	READ
TOU	問う	ASK
ŌJIRU	応じる	ANSWER
HANASU	話す	TALK
SHIMESU	示す	SHOW
RONJIRU	論じる	DISCUSS
OSHIERU	教える	TEACH
MANABU	学ぶ	LEARN
KANGAERU	考える	THINK
SHIRU	知る	KNOW
KESSURU	決する	DECIDE
KYŌSURU	供する	PRESENT
OMOU	思う	CONSIDER
KUWAERU	加える	ADD
GENJIRU	減じる	SUBTRACT
JŌJIRU	乗じる	MULTIPLY
JOSURU	除する	DIVIDE
KAGIRU	限る	LIMIT
TOKU	解く	SOLVE
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OYOBI
ARUIWA
SOSHITE
MATAWA
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